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Investigating Normal and Pathological Variation in Memory-based Inhibition: An Examination of Worry, Thought Suppression, and Stimuli Characteristics

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Investigating Normal and Pathological Variation in Memory-based Inhibition: An Examination of Worry, Thought Suppression, and Stimuli Characteristics

by

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Dissertation

Presented to the Faculty of the Graduate School of

The University of Texas at Austin

in Partial Fulfillment

of the Requirements

for the Degree of

Doctor of Philosophy

The University of Texas at Austin

August, 2009

Dedication

This dissertation is dedicated to Robert A. Brown. Your support has made my work possible. Your generosity, patience, kindness, and wisdom continue to teach me what is important in life. I hope to have the opportunity to give to others a fraction of what you have given to me. Thanks dad.

Acknowledgements

This dissertation was partially supported by the National Science Foundation, Dissertation Improvement Grant #BCS-0418331. Thank you to Claire Reinhold, who was instrumental in assisting with the organization, administration, and completion of data collection for a project of this scale.

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Publication No._____

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The University of Texas at Austin, 2009

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This work was conducted in an effort to better understand the role that activational mechanisms in memory play in the etiology and maintenance of anxiety disorders. The affect of word stimuli characteristics, such as affective valence and semantic association with worry, on the association between inhibition and trait worry was investigated under different types of induced thought. Previous research has demonstrated that worry is associated with negative affect, and that worry may be semantically organized in memory. Based on these findings, it was hypothesized that words would be differentially inhibited in association with trait worry when worry was induced compared to neutral thought. Stimuli characteristics including the positive or negative affective valence of words, and their semantic association with common domains of worry were expected to moderate the relationship between inhibition and trait worry. In order to investigate these hypotheses, 86 undergraduate students from the University of Texas at Austin completed a series of memory tasks designed to measure

inhibition for either negative or positive words, both associated and unassociated with worry. They underwent either idiopathic worry or neutral thought induction prior to completing each memory task, and completed questionnaires assessing trait worry and thought suppression. The findings provide partial support for the hypotheses. Higher levels of trait worry were associated with less inhibition of negative words, but more inhibition of positive words semantically associated with worry. Contrary to predictions, differential induction of worry did not affect the relationship between inhibition and trait worry. The research and clinical implications of these findings are discussed.

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INTRODUCTION

This introduction is designed to provide a literature review relevant to the study in three main areas including the processing of emotion in memory, the nature and functions of worry, and inhibition as a process in memory. Following the review, literature specific to developing the rationale for the study is integrated from these different areas. Upon establishing the rationale, an overview of the study is presented along with the hypotheses tested.

Emotional Processing in Memory

Emotional processing occurs across a broad spectrum of emotions. For the purpose of this investigation, the term emotional processing is used to specifically reference the processing of fear. The following sections on emotional processing provide a general background on network models of memory, a general theory of emotion and memory, and two theories of emotional processing, the latter of which posits a memory activation and elaboration framework for emotional processing.

Memory as a Framework for Emotion

NETWORK MODELS OF MEMORY: A BRIEF OVERVIEW

Information in memory is commonly represented in a network structure. Propositional networks provide one way to conceptualize how information is represented and structured in memory. In this model, a proposition serves as the smallest stand-alone unit of knowledge about which judgments or evaluations are made. Propositions serve as the building blocks of the network, and a set of propositions, each consisting of a set of relations and arguments, makes up a node (Anderson, 1995). A node is a larger

information structure reflecting ideas or concepts that consist of a set of propositions. Concepts or ideas (nodes) in a propositional network are interconnected or associated by links to shared propositions. For example, the concepts of “airplane” and “bird” would be linked in association by the propositional elements “wing” or “flight,” which they hold in common (Anderson, 1995). In addition, all of the propositions within a concept are associated with one another through their common associative link to the same concept.

Similar to propositional networks, semantic networks provide a structure for representing conceptual knowledge in memory (Quillian, 1966). Conceptual knowledge represents an abstraction of experiences to categories based on properties associated with those experiences (Anderson, 1995). Analogous to concepts and propositions in a propositional network, a category serves as a node that is comprised of associated properties. Similarly, categories with shared properties are linked to one another within the semantic network; also, all of the properties within a category are associated. This provides an important foundational basis for a number of characteristics in semantic networks regarding associations between properties and categories. One such characteristic is that the more frequently a property is encountered within the context of a category, the more strongly that property becomes associated with the category. This implies that experience alters the association strengths between categories and their properties. In addition, a higher frequency of accessing categories and/or their associated properties in memory results in a higher level of activation and lower activation threshold for these categories and properties (Loftus, 1974; Anderson, 1976).

Another important characteristic is that activation can spread from one category to another through the activation of shared properties (Collins & Loftus, 1975). For instance, consider the category “friends,” and the subsequent activation of the category “family”. The category “friends” includes a number of items (i.e. closeness, support, &

loyalty) that are properties of the category "family." Hence, activation of the category "friends" leads to activation of all properties in the category including closeness, support, and loyalty. Due to their simultaneous existence as properties within the category "family" these properties subsequently lead to increased activation of the category "family". This process, through which the activation of one category increases the activation of another category, is known as spreading activation (Collins & Loftus, 1975).

In a semantic network, both activation frequency and spreading activation play an important role in developing and modifying associations between categories and their associated properties. Levels of activation govern the likelihood that a particular memory will be accessed as well as how quickly it will be accessed (Loftus, 1974). Both the recency and frequency with which a memory has been accessed determine its level of activation (Anderson, 1976). The more recently or frequently a memory has been accessed, the more active the memory is, and vice versa. Another process that may play an important role in governing the level of activation in memory is inhibition, or the suppression of activation. This will be discussed in detail later.

EMOTION AND MEMORY

In the semantic network theory of mood and memory, Bower (1981; 1987) proposed that moods are embedded within the associative memory network as "special-purpose units (or nodes)." that contain sets of concepts, actions, and events. It is theorized that each primary emotion (i.e. sad, happy, angry, afraid, etc.) exists as a node within the semantic network. This theory provides a cognitive framework, based on memory, through which emotions are activated, modified, and appraised, and through which emotional states can be re-experienced based on recall of past emotional events. Under this theory, an emotion node is characterized by its inputs and outputs within the network, each containing a set of corresponding propositions (Bower, 1987). Input

propositions would include the set of environmental stimuli that cue the emotion, as well as judgments about the nature of the stimuli that would serve to modify its activation. Output propositions would consist of various responses associated with the emotion such as appraisal about the subjective importance of the emotion, behavioral and somatic responses, and labeling or classifying of the emotional experience. An important consequence of such a conceptualization is that it provides for a fluid system in which an emotion in memory may constantly undergo modification based on reciprocal influences exchanged between input and output propositions (Bower, 1987).

Consistent with the characteristics of semantic networks previously described, the frequency and recency of retrieving an emotional memory would result in a higher activation level of the emotion in memory, thus reducing its threshold for later activation. Further, spreading activation resulting from cueing a proposition associated with a particular emotion would increase the activation level of all of the other propositions associated with the emotion. Hence, cued input provided by activating the memory of an emotional experience would also activate the output propositions associated with the emotion, resulting in the initiation of emotional expressions and responses (Bower, 1987). For example, mentally picturing a time when someone fell out of a tree might result in activating the associated emotion of fear (not necessarily to the same degree) experienced during the initial event. In turn, the activation of fear would result in increased autonomic arousal and possibly cognitive re-appraisals reinforcing personal meaning to the nature of trees (i.e. height) or climbing, particularly that they are dangerous, represent threat, and should be avoided. Moreover, spreading activation would not be isolated to propositions about the specific event of falling from a tree. The activation level for all propositions associated with fear would increase, thus resulting in

a greater likelihood that other fearful events, such as almost getting hit by a car, would be recalled (Bower, 1987).

In addition to the theoretical implications involving spreading activation of emotion, Bower's theory also addresses how certain emotions and certain propositions for a specific emotion can be selectively activated. While a full review of this is beyond the scope of the current review, one aspect of this deserves comment. A mechanism that allows for the selective activation of certain propositions associated with an emotion would enable cognitive appraisal of an emotion in the absence of the subjective emotional experience and emotional responding. As will be dealt with later, inhibitory processes may play a role in governing selective activation in semantic networks in general, and through such networks the selective activation of different processes involved in emotion. Particularly, those related to the processing of fear.

In Bower's commentary (1987), he presents a number of predictions from this theory. First, that retrieval of information should be enhanced if the mood state during encoding is congruent with the mood state during retrieval. Second, perception and attention should favor mood congruent stimuli, resulting in mood congruent biases in perception and attention. In evaluating evidence related to these predictions, he presents a review of literature indicating that neither effect has been consistently identified in relation to induced mood state. More consistent, though equivocal mood congruent memory effects have been identified in association with longer standing or more chronic mood conditions including high levels of anxiety and depression (Gotlib & McCann, 1984; Mathews & MacLeod, 1985; MacLeod, Mathews, & Tata, 1986; Foa & McNally, 1986; Bower, 1987; Broadbent & Broadbent, 1988; MacLeod & Mathews, 1988; Matthews, Richards, & Eysenck, 1989; Mathews, 1990; Eysenck, Mogg, May, Richards, & Mathews, 1991; Mogg, Mathews, & Eysenck, 1992; Richards & French, 1992; Russo,

Fox, Bellinger, & Nguyen-Van-Tam, 2001). Further, studies support the proposition that emotional information is semantically organized (Altarriba & Bauer, 2004) and have demonstrated an additive effect of physiological arousal and semantic relatedness in enhancing recall of emotional words (Buchanan, Etzel, Adolphs, & Tranel, 2006). Mood states have also been shown to affect regions in the brain associated with semantic activity during the encoding of emotional words (Kiefer, Schuch, Schenck, & Fiedler, 2007).

As an explanation for the different pattern of results seen between induced and longer standing mood states, Bower (1987) offers a frequency of activation hypothesis. When the emotional state is long standing, mood related propositions are purportedly accessed and elaborated on more frequently. Thus, maintaining a higher level of overall activation for these propositions and consequent mood state. In contrast, an induced mood state is transient, and does not result in this repeated and frequent activation of information associated with the emotion. Consequently, it would not result in a higher activation level of emotion-based propositions and mood state. This explanation is consistent with findings discussed earlier that the increased retrieval frequency of information, within the framework of a semantic network model of memory, results in a higher level of activation for that information in memory, and a lower threshold for later activation of that information (Loftus, 1974; Anderson, 1976).

A particular problem for this theory is a relative paucity of findings that preferential recall of information is related to either current or long-standing emotional states, primarily anxiety states (Bower, 1987; Mogg, Mathews, & Weineman, 1987; 1989; Mathews, 1990; Mathews & Macleod, 1994, Mathews & Milroy, 1994a). One explanation of this posits that the recall biases that have been detected for anxiety are the result of a response rather than memory bias (Dowens & Calvo, 2003). In support of this,

Dowens and Calvo (2003) report findings in which no differences were found between high and low trait anxious participants on a surprise recall test of threat words lexically but not semantically processed after controlling for recall intrusions and recall sensitivity. They cite these findings as support for the proposition that a retrieval-based memory bias is not present for anxiety. Another possibility that will be explored in greater detail later is that failures to identify such effects in memory may result from methodologies requiring recognition or free-recall as outcome measures. Paradigms that yield measures of activational processes in memory, which are posited to underlie memory biases, may provide a more potent alternative strategy to overcome previous failed efforts to identify memory biases related to anxiety states.

EMOTIONAL PROCESSING OF FEAR

In an effort to provide a parsimonious framework to explain the relatively equivalent success of various fear reduction procedures, Rachman (1980) provides a working-definition of emotional processing. He states that emotional processing should be, "regarded as a process whereby emotional disturbances are absorbed, and decline to the extent that other experiences and behaviour can proceed without disruption." Furthermore, Rachman (1980) proposes that when emotional processing does not occur, intrusive signs of emotional disturbance will either persist or reoccur. Thus, failed emotional processing offers a potential explanation for the maintenance of fear, treatment non-response, and return of fear. As an example, consider an individuals initial exposure to a phobic stimulus such as a bee. While in the park, an individual encounters a bee for the first time and is stung. According to Rachman's (1980) definition, the emotional disturbance experienced as a result of getting stung should decline when successful emotional processing of the event takes place. In essence, the event was disturbing, but should not remain disturbing. To the extent emotional disturbance does not decline, it

may interfere with and disrupt other behaviors. In the case of being stung by a bee, this may be expressed in many ways, such as wearing heavy clothes outside during the heat for perceived protection against a potential bee encounter, or in more extreme cases, not going outside at all for fear of being stung again. According to Rachman (1980), this disruption of normal behavior arising from the initial event occurs because emotional processing for the event was not successful, and it will continue until successful emotional processing takes place.

The identification of emotional processing as playing an integral role in recovery from emotional disturbance partly derives from earlier research investigating the efficacy of imaginal exposure techniques in reducing fear (Rachman, 1980). Lang (1977) observed that lower levels of fear reduction using imaginal exposure during systematic desensitization was related to reduced heart rate reactivity during the exposure session. Consequently, it became important to ensure sufficient fear activation during therapeutic exposures by assessing indices of physiological arousal such as heart rate. In essence, successful fear reduction using exposure exercises requires sufficient fear activation, indexed by heart rate reactivity, which may not consistently result with mental imagery techniques.

In his exploration of factors likely to facilitate emotional processing, Rachman (1980) makes a connection between relaxation and an increased vividness of phobic imagery that later proves important for exploring the role of worry in emotional processing. In particular, he cites observations by Borkovec (1979) that relaxation training enhances the latency of sleep onset and reduces the occurrence of intrusive thoughts that interfere with sleep onset. This lays the groundwork for the possibility that different kinds of thought activity may (i.e. imaginal or verbal thought) interact with and/or influence one another with respect to the activation of fear.

Even given the large contribution of this theory, one significant limitation of Rachman's (1980) conceptualization of emotional processing is that it does not propose a mechanism that underlies emotional processing. That is, what process or processes provide the basis upon which fear is sufficiently activated to enable emotional processing?

In a theory exploring mechanisms that control emotional processing (Foa and Kozak, 1986; Rauch & Foa, 2006), it has been proposed that emotional processing occurs when information structures in memory, representing emotions, are modified. Thus emotional processing, considered the mechanism through which habituation to a feared stimulus occurs, functions through memory processes. It is argued that reduction of pathological fear requires sufficient activation of the fear structure in memory, and the incorporation of evidence contrary to at least some of the pathological elements of the fear structure. From a semantic network conceptualization, activation of the fear structure would require sufficient activation of its associated propositional elements in memory. In addition, modification of the fear structure would occur when disconfirming evidence (new propositions) has been incorporated into a new memory associated with the fear stimulus that no longer results in activation of the fear structure when cued by the stimulus. In essence, new conceptual knowledge of the stimulus is gained through experience, and new meaning associations about the threatening nature of the stimulus are developed and incorporated into memory-based representations of the stimulus. Holding to the view that fear structures in memory are semantic in nature, what distinguishes normal and pathological fears are their differential resistance to fear structure modifications (Foa and Kozak, 1986; Rauch & Foa, 2006). Normal fears are not resistant to fear structure modification, but pathological fears are.

This theory of emotional processing suggests that any cognitive process or behavior that limits the successful activation of the fear structure in memory, or the incorporation of new, inconsistent information, would consequently interfere with or prevent emotional processing. For example, variables such as distraction may influence emotional processing by reducing the degree to which fear structures are successfully activated, or hinder the processing of information incompatible with the fear structure (Foa & Kozak, 1986). Support for this has been provided by studies investigating the effect of attentional disruption on habituation of fear. Findings from these studies indicate that attentional disruption is sufficient to negatively influence emotional processing (Grayson, Foa, & Steketee, 1982; Sartory, Rachman, & Grey, 1982; Kamphuis & Telch, 2000; Telch, et al. 2004; Johnstone & Page, 2004; Dvorak-Bertsch, Curtin, Rubinstein, & Newman, 2007). According to emotional processing theory (Foa & Kozak, 1986; Rauch & Foa, 2006), when attention is disrupted or directed away from the threat, fear reduction is hampered by interference of attention with the incorporation of threat disconfirming evidence into memory.

The Nature and Functions of Worry

WORRY: THE EMERGENCE OF A CONSTRUCT

The emergence of worry as an important construct in the study of anxiety began in the late 1970s with the identification of intrusive cognitive activity (worry) at bedtime in individuals with insomnia (Borkovec, 1979), and the finding that worry rather than physiological arousal predicted poorer academic test performance in students (Deffenbacher, 1978; Deffenbacher, 1980; Deffenbacher & Hazelus, 1985). Coinciding with an evolving conceptual understanding of worry and the role it plays in anxiety

disorders, the diagnostic criteria for generalized anxiety disorder (GAD) underwent considerable transformation.

A universal diagnostic feature among anxiety disorders is the presence of persistent and excessive anxiety. In the Diagnostic and Statistical Manual of Mental Disorders, third edition (DSM-III; American Psychiatric Association, 1980), GAD served as a residual diagnostic category when persistent and significant anxiety was present and could not be better accounted for by another anxiety or mood disorder. As research efforts continued to increase understanding of the nature and functions of worry, worry was identified as playing a central role in GAD. Consequently, changes in DSM-III-R (APA, 1987) resulted in excessive and/or unrealistic worry as the central diagnostic feature of GAD, as long as the worry was identified in two or more life spheres and unrelated to another Axis I disorder.

In accordance with DSM-IV (APA, 1994), GAD is currently diagnosed when worry is excessive and uncontrollable, occurs across multiple life spheres (e.g., relationships, finances, health, work performance, etc.), lasts for a period of at least six months, is accompanied by at least three additional symptoms, and results in significant impairment or distress. Given these criteria, pathological worry may be differentiated from normal worry based on its frequency, controllability, and chronicity. In essence, normal worry becomes pathological when it becomes excessive, uncontrollable, and chronic.

The identification of worry as excessive is closely tied to determining whether the presence and amount of worry are realistic given the "objective" realities of an individual's circumstances. For example, constant worry about job loss would be considered excessive in an individual with a history of good performance evaluations, who has repeatedly been promoted, and has not recently received negative performance

feedback. In contrast, this same worry would not be considered excessive in an individual with a history of negative performance evaluations, and who has received repeated warnings in which potential job loss is a possible consequence for failure to improve performance.

The uncontrollability of worry is assessed by self-report and generally reflects an individual's self-perceived control over worry. While the chronicity of worry may be considered in a variety of ways, it is diagnostically determined based on the duration over which pervasive and unremitting worry has occurred. For instance, worry may be pervasive and unremitting if it continues in the face of evidence disconfirming the need for it, or worry may also be viewed as pervasive and unremitting if it occurs over a long period of time. The current diagnostic criteria employs the latter by requiring that worry occur more often than not over at least a six-month period.

In an exploration of the value of worry as a concept, Borkovec (1985) suggested that the manner by which cognitive patterns among anxiety disorders can be modified presents a "real challenge" to both basic and applied research. To meet these challenges, Borkovec (1985) suggested the initiation of research focused on clarifying the nature and functions of cognitive processes that underlie anxiety. To this end, a growing body of research has emerged with the primary goal of developing an understanding of the nature and functions of worry.

DISTINGUISHING BETWEEN WORRY AND ANXIETY

Identifying worry as a construct independent of anxiety has proven to be a challenging task. Until recently, the terms anxiety and worry have often been used interchangeably. This is not surprising given the high prevalence of worry among anxiety disorders (Barlow, 1988) and the difficulty of conceptually distinguishing the two (O'Neill, 1985; Borkovec, 1985; Mathews, 1990). Despite the challenges, a number of

studies have investigated whether worry and anxiety are indeed independent constructs (Zebb & Beck, 1998). One approach to investigating construct independence is the use of correlation strategies employed to ascertain the strength of association between measures of anxiety and worry, and to demonstrate their unique predictive value on other behavioral measures. Employing such strategies, a number of studies have yielded evidence supporting the independence of these two constructs (Zebb & Beck, 1998; Verkuila, Brosschota, & Thayerb, 2007). For example, trait worry and trait anxiety have been found to account for unique variance in both problem-solving and coping style among college students (Davey, Hamptom, Farrell, & Davidson, 1992; Davey, 1993; Belzer, D'Zurilla, Maydeu-Olivares, 2002), and the correlation between worry and trait anxiety in GAD patients is lower than in normal populations (Meyer, Miller, Metzger, & Borkovec, 1990). In addition, intolerance of uncertainty is highly associated with worry independent of anxiety and depression levels (Dugas, Freeston, & Ladouceur, 1997).

Despite emerging evidence suggesting that worry and anxiety are independent constructs, the anxiety literature does not consistently reflect the independence of these constructs. It is not uncommon to find the terms "worry" and "anxiety used interchangeably, as if they were synonymous. This lack of distinction in the face of contrary evidence may underlie more recent efforts designed to clearly delineate the boundaries of the worry construct in order to provide a meaningful and theoretically valid definition independent of the anxiety construct. One product of such efforts is the proposition that anxiety and worry may each serve as component parts of a larger anxiety construct. In this context, the label "anxiety" has been used to refer to somatic activity associated with potential threat, whereas "worry" has been associated with the engagement of cognitive processes in response to potential threat. The problem with this approach is that it ascribes to worry cognitive processes, such as the appraisal of present

threat, which may be more appropriately considered a component of anxiety than worry. As such, a definition of worry derived from empirical investigations into its nature and functions provides a conceptualization of worry that is not restricted or biased by attempts to define worry solely based on its distinction from anxiety.

CONCEPTUALIZING WORRY

Our understanding of worry has grown in richness and specificity. Shortly after its emergence as a construct meriting clinical and scientific attention, Borkovec, Robinson, Pruzinsky, and DePree (1983) offered the first detailed definition of worry.

> Worry is a chain of thoughts and images, negatively affect laden and relatively uncontrollable. The worry process represents an attempt to engage in mental problem solving on an issue whose outcome is uncertain but contains the possibility of one or more negative outcomes. Consequently, worry relates closely to fear process.

Since this definition was offered, significant research efforts have been dedicated to developing a more detailed and thorough understanding of both the nature and functions of worry. The results of these efforts have provided support for much of this definition, revisions where the evidence merits them, and an increased understanding of the contribution of individual differences to the process of worry. While evaluating the nature and functions of worry, it is important to consider that the concept of worry is commonly viewed as a pathological process. To the contrary, worry may be considered an adaptive process that serves important functions related to problem solving and cognitive appraisal. In this view, it is not pathological, but may become pathological through dysfunction or deregulation of mechanisms that control worry, or through processes that interfere with worry successfully achieving one of the functions it serves.

Problem Solving and Intolerance of Uncertainty

Whether problem solving is a feature of worry, an epiphenomenon of worry or a process independent of worry has yet to be clearly determined. As discussed previously, worry has been found to be associated with problem solving (Davey et al., 1992; Davey, 1993; Beltzer et al., 2002). However, the association between worry and problem solving doesn't establish worry as representing, in part or whole, an attempt at problem solving. Two studies examining the perceived functions of worry by employing self-report assessments of the reasons for worrying have provided stronger evidence that worry does, in part, include problem solving (Freeston, Rheaume, Letarte, Dugas, & Ladouceur, 1994; Borkovec & Roemer, 1995). Both of these studies found that one of the reasons reported for worrying was the identification of problem solutions. However, the findings also indicate that problem solving is not the only perceived function of worry. Individuals also reported worrying as a way to prepare for or minimize the effects of negative events. In addition, distraction from more distressing things was another reason cited for worrying. The strongest evidence suggesting that worry involves problem solving comes from a study by Szabo & Lovibond (2002). In an assessment of naturally occurring worry content, they examined self-monitoring diaries of worry episodes containing entries over a seven-day period and found that 48% of worry content was related to problem solving. While the preponderance of evidence suggests that worry does involve but is not limited to problem solving, some challenges remain in establishing the effects of worry on the efficacy of problem solving.

In an article exploring the cognitive functions of anxiety and worry, Mathews (1990) highlights the difficulties of defining worry as a problem-solving process by stating, "Worry thus resembles problem-solving in some respects; but instead of leading to a satisfactory outcome, it is as if the danger is constantly being rehearsed without a

solution ever being found." Given the previously reported findings, it could be reasonably hypothesized that worry would aid problem solving. However, to date the evidence seems to suggest that worry enhances some aspects of problem solving while at the same time interfering with others. Davey (1993) found that while chronic worriers reported lower confidence in their social problem-solving abilities than non-worriers, they do not report differences in their social problem-solving skills. Consequently, Davey suggests that worry may not influence the generation of solutions during problem solving, but rather it may be related to a reduced implementation of those solutions. This explanation would be consistent with Mathews (1990) observation that worry does not necessarily result in the resolution of a problem. Further, evidence of a disconnection between the generation of solutions and their implementation was found in a study of the self-reported consequences of worry (Davey, Tallis, & Capuzzo, 1996). The findings from this study indicate paradoxical consequences of worry related to problem solving. Worry was reported to both enhance analytical thinking about a problem and simultaneously exaggerate the problem. One explanation for the lack of solution implementation by worriers may be their lack of confidence in their ability to solve problems. Somewhat in contrast, Szabo and Lovibond (2006) report findings indicating that solution generation may actually serve as a strategy to end worry. However, this study did not address the role of pathological levels of worry, which by definition are excessive and uncontrollable.

The lack of confidence that worriers have in their problem solving ability and their failure to implement solutions to a problem may be tied to their intolerance of uncertainty. Tallis, Eysenck, and Mathews (1991) compared the response rates of high and low worriers on a letter-search task when a visual target was absent and assessed the correlation between retarded response latencies and a measure of worry frequency.

Retarded response latency on the letter-search task in the absence of a visual target served as an index of intolerance of uncertainty as it reflects the application of increased evidence requirements in performing the task. Consistent with increased evidence requirements, the findings showed that high worriers took longer to respond when the visual target was not present. Furthermore, a positive association between retarded response latencies and a measure of worry frequency was identified. These findings indicate that high worriers may require elevated levels of evidence prior to reaching a decision, and that elevated levels of evidence requirement are associated with an increased frequency of worry. As such, the inability to reach decisions, contingent upon increased evidence requirements, may serve as a maintaining factor for worry.

In an application of emerging evidence that intolerance of uncertainty plays a role in maintaining worry, Dugas et al. (1997) investigated the relationship between intolerance of uncertainty, problem orientation, and trait worry. In contrast to problem solving skills, which include defining a problem, generating alternative solutions, making decisions, and implementing solutions, orientation is characterized as a general response set when faced with a problem. A negative problem orientation is characterized by heightened threat perception related to problems, low confidence in problem solving ability, and a tendency to negatively predict problem outcomes (D'Zurilla & Goldfried, 1971; Robichaud & Dugas, 2005). The findings of Dugas and et al. (1997) indicate that whereas problem-solving skills are not associated with worry both intolerance of uncertainty and negative problem orientation are. Further, while intolerance of uncertainty and negative problem orientation share a considerable amount of variance in predicting worry, they also contribute unique variance to the prediction.

Measures of problem orientation and intolerance of uncertainty have also been shown to differentiate between individuals with GAD and moderate non-clinical worriers

(Ladouceur, Blais, Freeston, & Dugas, 1998). A model for GAD including intolerance of uncertainty, poor problem orientation, beliefs about worry, and cognitive avoidance was found to correctly distinguish with (82% correctly identified) between individuals with and without GAD (Dugas, Gagnon, Ladouceur, & Freeston, 1998). Evidence for the role of intolerance of uncertainty in worry and GAD has not been limited to studies employing correlation strategies. In a study manipulating intolerance of uncertain with a gambling procedure designed to induce or reduce intolerance of uncertainty, participants in the increased uncertainty condition demonstrated a higher level of worry than participants in the decreased uncertainty condition (Ladouceur, Gosselin, & Dugas, 2000). This finding is important because it highlights the potential causal effect of intolerance of uncertainty on worry. Individuals with a high intolerance of uncertainty have also been shown to demonstrate a recall bias for threat information and report a higher degree of concern when faced with ambiguous information (Dugas, et al., 2005). Additional research has identified intolerance of uncertainty as a predictor of worry (Dugas, Gosselin, & Ladouceur, 2001; Buhr & Dugas, 2006; de Bruin, Rassin, & Muris, 2006; de Bruin, Rassin, & Muris, 2007; Khawaja & Chapman, 2007), as a risk factor for worry (Norton, Sexton, Walker, & Norton, 2005), and a potential cognitive vulnerability for excessive and uncontrollable worry (Koerner & Dugas, 2008).

Summary

Investigations into the link between worry and problem solving have led to a much better understanding of the role worry plays in problem solving. The findings suggest that while worry may not be solely characterized as a problem-solving process, one reason for worrying does include the generation of solutions to a problem. However, as worry is not associated with problem solving skills, the failure to implement but not generate problem solutions appears to be tied to a decreased confidence in problem-

solving abilities among worriers. That is, worriers generate potential solutions to problems, but they don't put those solutions into action due to a lack of confidence in their ability to solve the problem. This consequently results in unresolved problems. Lack of confidence in problem-solving abilities among worriers may arise from poor problem orientation and/or an intolerance of uncertainty, both of which have been identified as strong predictors of worry. Poor problem orientation and intolerance of uncertainty have also been found to distinguish between individuals with and without GAD. Further, some evidence suggests that intolerance of uncertainty may have a casual role in increasing worry.

Worry as a Cognitive Process

Worry as Verbally-oriented Thought

The characterization of worry as a chain of thoughts is valid prima facie. However, the inclusion of images in this chain has been challenged to a certain degree. Evidence from various research efforts suggests that worry may be better characterized as a verbally oriented thought process that is less oriented toward images than non-worry cognitions (Borkovec & Inz, 1990; Tallis, Davey, & Capuzzo, 1994; Freeston, Dugas, & Ladouceur, 1996). While assessing thought content during periods of relaxation and worry, Borkovec and Inz (1990) found that periods of worry in both GAD clients and non-anxious controls were characterized by a predominance of verbal thought activity relative to mental imagery. This is in contrast to a predominance of mental imagery reported by controls during relaxation periods. GAD clients reported approximately equal amounts of thought and mental imagery during relaxation periods. This is important as verbal thought has been shown to result in less arousal associated with fear than mental imagery (Tucker & Newman, 1981; Vrana, Cuthbert, & Lang, 1986), which

would reduce the efficacy of desensitization exposures requiring sufficient fear activation in order provide habituation. Further, these results seem to suggest two important characteristics of worry. First, that the act of worrying reflects an increase in verbal thought activity. Second, that cognitive correlates of worry appear to be active in individuals with GAD even during periods of relaxation.

The proposition that worry predominantly involves verbally oriented cognition received further support when Rapee (1993) employed tasks requiring utilization of the different components of working memory (the central executive, the phonological loop, and the visuo-spatial sketchpad). The phonological loop and visuo-spatial sketchpad are two of three working memory stores in which visuo-spatial and phonological sensory input are briefly stored. Attention to information to be retained for further encoding is managed by the central executive of working memory. Rapee assessed which of these aspects of memory were activated during worry by having participants engage in worry while performing these tasks. Rapee's findings indicate that tasks requiring simultaneous use of the phonological loop and central executive interfered with worry the most, and that tasks employing the visuo-spatial sketchpad and the central executive associated with visuo-spatial processing had little influence on worry. Not only do these findings isolate worry as a verbally mediated phenomenon, but they point to the possibility that the central executive of working memory may have independent components associated with phonological and visuo-spatial processing (Rapee, 1993). In, another study investigating the affect of worry on working memory, no association between verbal working-memory and worry was found on either a forward digit span task, or reversed digit span task that places a resource load on the phonological loop (Crowe, Matthews, & Walkenhorst, 2007). However, worry was found to be associated with tasks utilizing the central

executive of working memory, suggesting that worry takes up resources required by the central executive to redirect attention.

Another way to assess the relative increase in verbal thought activity associated with worry is by comparing it to an assessment of thought activity associated with obsessions (Turner, Beidel, & Stanley, 1992). Using a non-clinical population, Langlois, Freeston, and Ladoucer (2000) had participants identify and describe an obsession-like intrusion and a worry, and then evaluated them with the Cognitive Intrusion Questionnaire (Freeston, Ladouceur, Thibodeau, & Gagnon, 1992). Consistent with other findings (Wells & Morrison, 1992), they found that obsession-like intrusions consisted of more imagery while worry consisted of more verbal, thought activity. Lastly, in a study comparing left (verbally oriented) to right (visuouspatially oriented) interhemispheric communication, high worriers were found to transfer threatening images slower than low worriers (Compton, et al., 2008). These findings seem to indicate that threat information is more slowly translated into image based representations through interhemispheric communication among high worriers. A synthesis of the above findings suggests that worry is an internal thought process that primarily consists of verbal cognitive activity and content that is activated in response to a triggering stimulus. Identifying the precipitants of worry further clarifies both its nature and functions.

Thematic Content of Worry

Worry may be activated in anticipation of negative events, and tends to be organized into a number of primary themes. While worry occurs primarily in anticipation of potential negative consequences, it is not limited to future events. Worry about past events has been reported to comprise as much as 20% of worry content (Borkovec et al., 1983). Recordings of naturally occurring worry content have identified that 48% of worry reflects problem solving, 17% involves future negative outcomes, and 11% can be

identified as rumination, defined as negative aspects of a present or past situation or person (Szabo & Lovibond, 2002). While the percentages vary, a significant, but smaller portion of worry does appear to be focused on past events.

The identification of primary themes of worry has been relatively consistent across a number of studies. In a study of individuals with GAD, Sanderson and Barlow (1990) categorized the content of worries obtained in clinical diagnostic interviews as most commonly relating to life spheres including family, finances, work, and illness. Similar themes have been identified in a non-clinical population. In the development of a measure of non-pathological worry (Tallis, Eysenck, & Mathews, 1992), worry was found to cluster into categories including relationships, lack of confidence, aimless future, work incompetence, and finances. Differences between these two category schemes may reflect differences in the dimensions of normal and pathological worry. In a study comparing individuals with and without GAD, Craske, Rapee, Jackel, and Barlow (1989) found that individuals with GAD worried more about issues of health, illness and injury than did individuals without GAD. In addition, individuals with GAD were found to worry more about miscellaneous issues. This has been supported by results from a similar study by Roemer, Molina, and Borkovec (1997). However, Roemer and colleagues found the most frequent category of worry reported in both groups involved family and interpersonal issues, and individuals with GAD, while high on worries related to work/school, reported lower frequencies of worry in these areas than individuals without GAD. In a more recent investigation, Berenbaum, Thompson, and Pomerantz, (2007), identified achievement as the most frequent life domain participants worried about, followed by interpersonal and health concerns. While there are minor differences in the category schemes proposed for worry, there appears to be agreement that worry primarily involves the categories of work/school, family/relationships, finances, and

health. In addition, individuals with GAD tend to differ somewhat in the category they most frequently worry about, and tend to worry more about miscellaneous concerns.

Worry and Negative Affect

Worry appears to occur primarily in anticipation of potential negative consequences. A study by Macleod and Byrne (1996) has also demonstrated that individuals who score high on a measure of trait worry anticipate more future negative experiences than do individuals who score low on trait worry. As worry seems closely tied to potential or past negative consequences, it seems intuitive that worry is associated with negative affect. Nevertheless, there is evidence to support this association (Borkovec at al. 1983; Beck, Perkins, Holder, Robbins, Gray, & Allison, 2001) as well as to suggest that worrying produces negative affect (York, Borkovec, Vasey, & Stern, 1987; Andrews & Borkovec, 1988; Borkovec & Inz, 1990; McLaughlin, Borkovec, & Sibrava, 2007). A study by Fresco, Frankel, Mennin, Turk, and Heimburg (2002) investigated the association between worry, rumination, anxiety, and depression in a non-clinical population. They identified two worry factors from the Penn State Worry Questionnaire (PWSQ; Meyer, Miller, Metzger, & Borkovec, 1990) including worry engagement and absence of worry. Employing tests of independent correlations (Bruning & Kintz, 1987), they found a stronger association between worry engagement and symptoms of depression than the association between a measure of cognitive appraisal and symptoms of depression. This indicates that the association between worry and negative affect is not a function of the cognitive appraisal characteristics of worry, but rather the degree to which and individual engages in worry. An analysis of thought content during episodes of neutral thought and episodes of worrisome thought indicates that episodes of worry contain more negative-affect content (Molina, Borkovec, Peasley, & Person, 1998). Consequently, deeper engagement in worry may result in increased

exposure to negative affect-laden content, in turn likely increasing the subjective experience of negative affect.

The Structure of Worry Content in Memory

Worry related content in memory appears to be organized around worry areas or domains (Craske, et al., 1989; Sanderson & Barlow, 1990: Tallis, et al., 1992; Roemer, et al., 1997) with content that is tightly clustered together and highly associated (Eysenck, 1984; Pratt, Tallis, & Eysenck, 1997; Provencher, Freeston, Dugas, Ladouceur, 2000).

Consistent, with Bower's (1981; 1987) semantic network theory of mood and memory, worry related content appears to be organized in memory in a manner similar to that proposed for emotion-based content (Eysenck, 1984; Pratt, et al., 1997; Provencher, et al., 2000). As worry is activated in response to and thereby associated with potential threat, and is associated with negative affect, it would be intuitively consistent to posit the existence of worry categories or nodes within the semantic memory network. As such, the clustering and strong association of worry-related information within this network would likely enhance the process of spreading activation, and result in the priming of associated worry-related information (Eysenck, 1984; Pratt, et al., 1997; Provencher, et al., 2000). Consequently, worry-related content in memory may be more easily activated due to an increased activation level and lower activation threshold. This in turn may result in a higher activation frequency of worry content in memory due to greater cueing sensitivity inherent in already primed material. As previously discussed (Loftus, 1974; Anderson, 1976), a higher activation frequency in turn leads to a higher level of activation and lower activation threshold, thus establishing a semantic memory based mechanism through which activation of worry would be capable of both maintaining and increasing itself.

Summary

Investigations of the association between worry and negative affect have revealed that worry engagement is more strongly associated with symptoms of depression than cognitive appraisal. In addition, worry includes a greater amount of negative affect thought content than does non-worry related thought. As worry has been shown to result in increased negative affect, deeper or more frequent engagement in worry would result in further exposure to negative affect-laden content that may further increase subjective experiences of negative affect. Thus far, worry appears to consist of a chain of predominantly verbal thoughts that are activated in response to potential or past negative events, and generally focused on one or more themes including work/school, family/relationships, finances, and health. Episodes of worry are associated with greater negative affect and involve negatively affect-laden content. Worry-related content is likely structured within a semantic memory framework in which the content is tightly clustered and highly associated. This clustering and strong association of worry-related information would likely increase the activation level and activation frequency of worry-related content in memory, resulting in enhanced spreading activation in memory and reducing the threshold for worry activation.

Uncontrollable Worry and Thought Suppression

Controllability

Difficulty controlling worry is a central diagnostic feature of GAD, and the proposition that worry in GAD is relatively uncontrollable has received confirmatory support form a variety of areas. In a study comparing individuals with and without GAD on dimensions of worry, Craske et al. (1989) found that individuals with GAD rated their worry as less controllable than individuals without GAD. In addition, individuals with

GAD tended to rate their worry as relatively uncontrollable while individuals without GAD tended to rate their worry as relatively controllable.

Thought Suppression

Another approach to evaluating the difficulty of controlling worry is to evaluate the success of attempts to suppress worrisome thoughts. Although few studies have investigated efforts to suppress worrisome thoughts (Mathews, & Milroy, 1994b; Becker, Rinck, Roth, & Margraf, 1998) and the results are mixed, assessing success or failure of thought suppression related to worry may offer important insights into the nature of pathological worry.

The research on thought suppression has grown out of findings that thought suppression exerts a paradoxical effect. Attempting to suppress thoughts actually results in a greater frequency of their occurrence (Wegner, Schneider, Carter III, & White, 1987). In a study comparing high and low non-clinical worriers, Mathews and Milroy (1994b) primed participants with either a brief period of worry, suppression of worry, or non-worrying thought. Following this priming period, they had participants record their thoughts at several intervals, and found that high worriers had more worry related repetitions across both worry conditions (engage in worry or suppress worry) than low worriers. While the authors cite their findings as a lack of evidence for the hypothesis that suppression of upsetting thoughts (worry) increases their intrusiveness, this may be an unwarranted conclusion from the findings. Consistent with the paradoxical effects of thought suppression, it may be argued that both attempts at suppressing worry and engaging in it serve to prime worrisome thoughts, and that priming is the mechanism through which both of these conditions produced increased worrisome thoughts. This explanation may also account for the finding that high worriers reported more, worrisome thoughts and less positive thoughts than low worriers across conditions.

In contrast to Mathews and Milroy's (1994b) findings, Becker et al. (1998) found that individuals with GAD had more difficulty suppressing worrisome thoughts than other thoughts in contrast to the opposite pattern seen in individuals with public speaking phobia and non-anxious controls. This finding is important as it isolates difficulties in suppressing worrisome thoughts to individuals with GAD whereas individuals without GAD can suppress worrisome thoughts more effectively. In addition, the findings indicate that individuals with GAD do not have difficulty suppressing all thought activity, but rather have particular difficulty in suppressing worrisome thoughts. As discussed previously, explanation of these findings may be related to the structure of worry content in the memory of individuals with GAD.

Cognitive Intrusions and Impairment of Attention

Further support that worry may be relatively difficult to control comes from findings that worry results in cognitive intrusions (Borkovec et al., 1983; York et al., 1987). By definition, an intrusive thought is difficult to control. Researchers investigating the role of intrusive cognitions and worry have compared deficits in attention-focused tasks following exposure to either a worry or non-worry condition (Borkovec et al., 1983; York et al., 1987). Regardless of clinical status, the findings have identified greater attentional impairment in individuals in the worry condition than in the non-worry condition. The disruption of attention subsequent to worry activation is believed to result from cognitive intrusions related to worry. As evidence for this, one study sampled participants' thoughts at several intervals during the attention focused task, ensuring that worry related thought content was present during the task (Borkovec et al., 1983). In discriminating the effect of worry on attention, attentional impairment has been isolated as occurring in worriers (Pruzinsky & Borkovec, 1990). Further evidence supports for the proposition that worry influences attentional mechanisms. For example,

worry has been associated with greater attentional interference on dichotic listening tasks (Mathews, & Macleod, 1986) as well as modified Stroop tasks (Stroop, 1935; Mogg, Mathews & Weiman, 1989; Mathews & Klug, 1993), and has been associated with an increased load on resources required by the central executive of working memory (Crowe, Matthews, & Walkenhorst, 2007; Hayes, Hirsch, & Mathews, 2008). Most recently, the combination of high trait worry and high state anxiety were found to result in impaired attentional disengagement from threat stimuli (Verkuil, Brosschot, Putman, & Thayer, 2009), indicating greater attentional focus directed toward threat.

Summary

Findings from research in several areas including controllability of worry, thought suppression, and thought intrusions have provided greater insight into the uncontrollable nature of worry, especially when it is considered pathological. Individuals with GAD tend to rate their worry as relatively uncontrollable. In contrast, individuals without GAD tend to rate their worry as relatively controllable. The difference between individuals with and without GAD in controlling their worry has been reflected in findings investigating the suppression of worrisome thoughts. While, individuals with GAD have more difficulty suppressing worrisome thoughts, this deficit appears to be restricted to worry-related thoughts, not all thoughts. It also appears to be specific to GAD, as individuals with public speaking phobia do not show this same difficulty. While difficulty in suppressing worrisome thoughts has been shown to distinguish between individuals with and without GAD, intrusive worrisome thoughts have been shown to occur in participants subsequent to the activation of worry regardless of their clinical status. This latter finding, in combination with findings derived from controllability studies and thought suppression studies, suggests that while worry results in an increased level of worry related cognitive intrusions, the ability to suppress those

thoughts, and thus exert control over worry, differs depending on an individual's clinical GAD status.

WORRY AND EMOTIONAL PROCESSING

Based on evidence suggesting that worry is activated in response to perceived threat (potential negative event), it would be reasonable to infer that worry serves an important function related to threat and concomitant fear processes. In order for emotional processing to occur, sufficient activation of target fear structures in memory must take place and information incompatible with the fear structures must be incorporated into new memories (Foa & Kozak, 1986; Rauch & Foa, 2006). Consequently, processes that interfere with the activation of fear structures would interfere with emotional processing and result in the maintenance of fear. Borkovec and his colleagues (Borkoec & Inz, 1990; Borkovec & Hu, 1990) have proposed that worry may interfere with emotional processing by suppressing fear activation in response to perceived threat. Therefore, suppressed fear activation may provide a mechanism for fear avoidance through which worry may be negatively reinforced and thus maintained (Borkovec, Ray, & Stober, 1998).

The proposition that worry suppresses fear activation and interferes with emotional processing has been supported by a number of findings. In an experiment on the effect of worry on cardiovascular response, Borkovec and Hu (1990) had participants with public speaking anxiety undergo a period of relaxation, neutral thought, or worry prior to imaginal exposure of a public speaking scenario. In a comparison of heart rate during imaginal exposure, they found that heart rate in response to phobic imagery increased less for individuals in the worry than non-worry condition. As heart rate provides a physiological index of fear activation, these findings were presented as an indication that worry suppresses subsequent fear activation and consequent emotional

processing. Subsequent studies have obtained similar results (Peasley-Milkus & Vrana, 2000; Castaneda, & Segerstrom, 2004), with others restricting this effect to worry involving verbal thought rather than mental imagery or affective focus (Borkovec, Lyonfields, Wiser, & Deihl, 1993), and identifying differences between individuals with and without GAD (Thayer, Friedman, Borkovec, Johnsen, & Molina, 2000). Further, worrisome thinking was found to negatively predict heart rate reactivity to phobic images. In contrast, relaxation positively predicted heart rate reactivity (Borkovec et al., 1993). This is consistent with other findings suggesting that verbalization of provocative material results in less physiological arousal than images of provocative material (Vrana, Cuthbert, & Lang, 1986), and that verbalization has also been shown to decrease physiological arousal in response to aversive stimuli (Tucker & Newman, 1981). Finally, heart rate reactivity in individuals with GAD has also been associated with orienting and defensive responses, implying aberrant attentional control (Thayer et al., 2000).

SUMMARIZED CONCEPTUALIZATION OF WORRY

This summary provides a focused review of the material presented about worry up to this point that has particular relevance to the rationale underlying this study and future sections in this paper. Thus far, worry appears to consist of a chain of predominantly verbal thoughts that are activated in response to potential or past negative events. The content of worry appears to be generally focused on one or more themes including work/school, family/relationships, finances, and health. Episodes of worry are associated with greater negative affect and involve negatively affect-laden content. Worry-related content is tightly clustered and highly associated in memory and likely structured within a semantic memory framework. Given the theoretical properties ascribed to semantic networks, this may have important implications for the maintenance of worry related cognitive activity, which may play a potential role in worry pathology. Finally, worry

has been show to have intrusive cognitive qualities, which may become difficult to control or suppress and interfere with attention.

Inhibition in Memory

The exploration of inhibitory processes related to psychological phenomena has become increasingly prominent across various psychological disciplines. This is likely a reflection of inhibitions broad utility as an explanatory concept. However it has also resulted in an ill defined application of inhibition as a concept. In general, inhibition is defined as a process that results in the suppressed activation or initiation of a subsequent event. For the purpose of this review, the following exploration of inhibitory processes will be restricted to the role of inhibition in memory.

RETRIEVAL INDUCED FORGETTING: NON-VOLITIONAL INHIBITION

Recently, inhibitory processes have been implicated as playing a role in the activation of semantically related content in memory (Anderson Bjork, & Bjork, 1994; Anderson & Spellman, 1995). As such, inhibitory processes may also play an important role in the experience and appraisal of mood activated through processes in memory. For example, inhibition may serve as one mechanism through which Bower (1987; 1989) has proposed that the appraisal of information and/or stimuli associated with mood can occur independently of an emotional response. As presented previously, a mechanism allowing for such a process would be evolutionarily advantageous, allowing for individuals to make decisions and respond based on evaluation of mood instead of acting reflexively, forced to respond to their emotional experience.

Consistent with a dual process model of memory retrieval, activation of target material for retrieval from memory may spread broadly across target associated material. Inhibition may suppress the activation of associated non-target material, aiding in the

selective activation and retrieval of targeted material, but not associated non-target material. Applying similar processes to the activation of different propositions in memory related to mood, spreading activation may result in the increased activation potential of all propositions related to the mood, while inhibition may function to suppress those associated propositions involved in initiating the mood experience. Thus, similar to the role of inhibition in a dual process model of memory retrieval, inhibition may aid in the selective activation of information necessary for mood appraisal by suppressing associated mood propositions involved in mood activation. For example, an individual who was mugged in a grocery store parking lot would have propositions related to being mugged that would include such things as parking lots are dangerous and it is not safe to leave a grocery store. Other propositions about muggings would be response associated such as run, call for help, do exactly what you're told, or fight. Inhibition of response associated propositions (i.e. run, fight) would enable an individual to appraise the degree of threat they assign to parking lots so that they are not in a state of perpetual responding. Further, the ability to suppress behavioral responding and cognitively appraise information associated with the fear of being mugged would aid an individual in emotionally processing and recovering from the traumatic experience of being mugged (Foa & Kozak, 1986; Rauch & Foa, 2006).

The hypothesis that inhibition may serve as a companion process to excitation in selectively activating content in memory is supported by research on retrieval induced forgetting (Anderson et al, 1994; Anderson & Spellman, 1995). In retrieval induced forgetting, inhibition is believed to serve as a mechanism that suppresses the activation of associated non-target material, thus aiding in the selective retrieval of target material from memory. Employing the retrieval practice paradigm (RPP), Anderson et al. (1994) and Anderson & Spellman (1995) demonstrated that the repeated retrieval practice of

category nouns resulted in a later recall decrement for other, category-associated nouns, that were not practiced compared to the recall of category-unassociated nouns that were also unpracticed. The difference in recall between unpracticed words associated with versus unassociated with the retrieval-practiced words provides a measure of inhibition. Some debate remains as to whether the retrieval induced forgetting effect actually results from inhibitory processes in memory (Johansson, Aslan, Bauml, Gabel, & Mecklinger, 2007; Bauml, 2007), or whether other processes may better account for the effect (Perfect, Moulin, Conway, & Perry, 2002; Camp, Pecher, & Schmidt, 2007). However, the preponderance of evidence favors an inhibitory account of retrieval induced forgetting for explicit memory tests where retrieval practice is conducted in a category stem-cue format.

As inhibition occurring through retrieval induced forgetting is not posited to result from motivated attempts to suppress the retrieval of unpracticed words, it may be conceptualized as a non-volitional form of inhibition in memory that occurs through automatic processes. Further, because non-volitional inhibition occurs through non-conscious, automatic processes, it may reflect and thus serve as a potential measure of inhibitory capacity.

DIRECTED FORGETTING: VOLITIONAL INHIBITION

Another manifestation of inhibition in memory occurs through motivated efforts to forget information. In investigations of directed forgetting (Elmes, Adams, & Roediger, 1970; Epstein, 1970; Block, 1971; Epstein & Wilder, 1972; Bjork & Woodward, 1973), participants receive instructions to either forget or remember stimuli presented for learning. Later participants were instructed to recall all stimuli regardless of the previous instructional set. Inhibition of to-be-forgotten words has been proposed as one explanation for the findings that participants recall less to-be-forgotten than to-be-

remembered words (Bjork, 1989; MacLeod, 1989). While the role of inhibition as a mechanism underlying directed forgetting effects is still under debate, the evidence tends to indicate that inhibition is one of the primary mechanisms underlying directed forgetting using the list method (Basden, Basden, & Gargano, 1993; Johnson, 1994; MacLeod, 1999). Other processes such as differential encoding are likely responsible for directed forgetting that occurs with the item-by-item method (Woodward & Bjork, 1971; Basden et al., 1993). In the list method of the DFT, participants receive instructions to forget words they were just presented for learning after half of the words from an entire word list have been presented. Inhibition of to-be-forgotten words is reflected in the free recall difference between to-be-remembered and to-be-forgotten words. Because this inhibition is believed to result from motivated attempts to forget material, it may be conceptualized as a volitional form of inhibition in memory.

Worry, Emotional Processing, and Memory-based Inhibition

INHIBITION AND SEMANTIC NETWORK THEORIES OF EMOTION AND MEMORY

Memory-based theories of emotion and emotional processing (Bower, 1981; 1987; Foa & Kozak, 1986) have been offered to provide a cognitive framework capable of explaining variation in emotional activation and experiences. Findings that emotion-related stimuli may be differentially processed depending on induced or long standing mood state have been offered to support his framework. However, while these theories possess explanatory value for findings that some induced and most long standing emotional states (particularly anxiety) are commonly associated with biases for attending to, perceiving, and processing mood congruent stimuli, they appear inadequate to account for an at-best inconsistent ability to detect similar biases in recall.

Differing explanations may account for the failure to consistently detect emotion-based biases in recall related to anxiety. One possibility is that the ability to detect such recall effects is methodologically dependent, and that a methodology capable of reliably demonstrating such effects has not yet been identified. Another possibility is that the current theoretical models are inadequate in this regard. Current evidence suggests that both explanations may be likely.

A predominance of failures to detect emotion-based recall effects, primarily related to anxiety, may be due to a reliance on methodologies using recall (i.e. number of words recalled) as an outcome measure to compare the effects of mood state (induced or long standing) or stimuli characteristics (mood congruent vs. mood incongruent) on memory. A more effective approach may be to rely on the use of memory-based paradigms that are capable of capturing underlying processes hypothesized to be involved in governing the activation of information in memory. A number of studies have employed such paradigms successfully, including directed forgetting tasks (Elmes, Adams, & Roediger, 1970; Epstein, 1970; Block, 1971; Epstein & Wilder, 1972; Bjork & Woodward, 1973) and the retrieval practice paradigm (Anderson, Bjork, & Bjork, 1994, Anderson & Spellman, 1995), to investigate the association between inhibitory functioning in memory and factors including mood (Power, Dalgleish, Claudio, Tata, & Kentish, 2000; Barnier, Hung, & Conway, 2004; Bauml & Kuhbandner, 2007; Minnema & Knowlton, 2008), dissociation (Elzinga, Phaf, Van Ardon, & Dyck, 2003) personality (Korfine & Hooley, 2000), response to traumatic stress (Zoellner, Sacks, & Foa, 2003; Cottencin et al., 2006; Geraerts & McNally; 2008, Amir, Badour, Freese, 2009), anxiety (Amir, Coles, Brigidi, & Foa, 2001; Zoelnner, Sacks, & Foa, 2003;), and worry (Brown, Tucker, & Telch, unpublished manuscript).

The emerging growth of findings that inhibitory processes in memory may play a significant role in several areas including normal and pathological variations in emotion, and even personality, suggests that current memory-based theories may be well advised to incorporate inhibitory processes as operational mechanisms within the theory. It is suggested that incorporating inhibitory processes as a mechanism within a theoretical framework would enhance the viability of existing or new memory-based theories of emotion and emotional processing.

This proposition is partially supported by the previously cited studies, but it is further grounded in a logical argument based on an apparent disconnect between the memory-based theories of emotion presented and known neurological processes. While an in depth review of the neurological underpinnings of cognition and emotion are beyond the scope of this review, a couple of basic statements should suffice for the proposed argument. At multiple levels of neurological functioning, including neuronal communication and communication between different regions in the brain via neural pathways, activation of neural processes is not solely determined by excitatory influences. Inhibitory processes play an integral, companion role in governing the activation of neural processes. As such, cognitive theories that rely solely on differential levels of activation, without incorporating inhibition as a mechanism involved in control of such activation, fail to provide an information processing framework consistent with the functional characteristics understood to govern neurological processes. Recent empirical support for such a position has emerged from a study investigating the neurological underpinnings of memory suppression (Anderson, Ochsner, Kuhl, Cooper, Robertson, Gabrieli, et al., 2004). Using event based fMRI during the administration of a think/no-think task, Anderson et al. (2004) found that suppression of unwanted memories corresponded with increased dorsolaterial prefrontal cortex activation. An area of the

brain believed to be important in emotional and behavior regulation through its inhibitory output to other brain regions. In addition, reduced hippocampal activation was also related to control of unwanted memories. Both increased prefrontal cortical activity and decreased right hemispheric hippocampus activity predicted the degree of forgetting in this task.

Even given the arguments and evidence presented, asserting the importance of incorporating inhibitory processes into memory theories of emotion must remain equivocal until a number of questions can be addressed. There currently is little understanding of the factors that influence both normal and pathological variation of inhibitory functioning in memory. Specifically with respect to a semantic network theory of mood (Bower, 1981; 1987), how might memory-based inhibition vary with respect to categorical associations of stimuli versus more general affective qualities? Further, how might these category and affective qualities interact to influence inhibition? In a different vein, other questions meriting investigation are inspired by the possible existence of different forms of inhibition in memory. More specifically, how might volitional inhibition, arising from motivated efforts to forget information, be related to non-volitional inhibition, arising from more automatic forgetting processes resulting from retrieval induced forgetting? It is possible that each of these forms of inhibition function independently; however this seems unlikely. Positing that non-volitional inhibition driven by automatic processes may provide a measure of inhibitory capacity, non-volitional inhibition may serve to mediate the relationship between volitional inhibition and factors found to influence it.

MEMORY BASED INHIBITION AND EMOTIONAL PROCESSING

In the theory of emotional processing (Foa & Kozak, 1986; Rauch & Foa, 2006), emotional processing is defined based on the processing of fear, the reduction of fear for

a stimulus or event based on integration of counter-threat evidence in memory. As fear is one of the primary mood states, it would be one of the emotions included in a semantic network theory of emotion and memory (Bower, 1981; 1987). Therefore the arguments presented in the preceding section, relating to the inclusion of inhibition as a mechanism in a memory-based theory of emotion, would be applicable to emotional processing. However, it is presented here distinctly to highlight a number of important consequences and factors involved in the processing of fear, further supporting the suggestion that inhibitory processes may play an important role in governing memory-based emotional activation in general, and play a specific role in emotional processing of fear.

In Bower's commentary (1987) on his semantic network theory of mood and memory, he raises the point that the activation characteristics of a semantic network would enable the activation and cognitive appraisal of an emotion without resulting in the simultaneous subjective experience, physiological response, and initiation of behavioral responses associated with the mood. With respect to fear, this has significant adaptive implications. Absent the ability to suppress behavioral responding and physiological arousal in order to accurately appraise threat, an individual would have a maladaptive tendency to over-respond to many environmental threat cues that do not represent "true" threat. However, cognitive threat appraisal alone, constantly absent physiological and behavioral threat responses, would be equally maladaptive, increasing the likelihood of bodily injury or early death. Therefore, an adaptive system must work to integrate these processes in a manner that results in suppression of physiological and behavioral responses when the threat is appraised as "false", but increased activation when the threat is appraised as "true." Similarly this system must be capable of suppressing cognitive appraisal in favor of immediate action when threat is imminent. In order to accomplish such goals there must be a system of communication that allows for reciprocal feedback

between these processes, and enables both the activation and suppression of responses based on situational demands.

LeDoux (1989; 2000) has proposed a dual pathway theory of emotional activation in the brain that is capable of satisfying the adaptive demands just presented. In this model, two emotional pathways including a fast and slow path exist. The fast path initiates in brain structures responsible for quick behavioral and physiological responses, and the slow path initiates in brain structures that are involved in executive functions such as planning and appraisal. The set of neurological structures involved in each pathway are capable of influencing each other through both excitatory and inhibitory inputs. Thus, the slow path can suppress fast-path activation of physiological arousal and behavioral responding in favor of further threat appraisal, and the fast path can suppress or override slow-path activation in order to suspend cognitive threat appraisal in favor of immediately initiating physiological arousal and behavior necessary to successfully cope with imminent threat. Although LeDoux's (1989; 2000) theory focuses on the neurological foundations for processing emotion, with important implications for the processing of fear, it may also offer insight into the mechanisms required in a semantic memory model of emotional processing. More specifically, if inhibitory processes capable of suppressing situation-dependent maladaptive fear responses function at a neurological level, it would be consistent to posit analogous inhibitory processes at work within the memory system capable of yielding the same results.

MEMORY-BASED INHIBITION AND WORRY

The prospect that inhibition may play an important role related to worry is implied by a number of characteristics related to the nature and functions of worry and the theoretical properties posited to exist in semantic network theories of memory, particularly those involving memory and emotion. Worry-related content in memory

appears to be tightly clustered, highly associated, and organized around central themes, implying that worry-related content may fit well within a semantic network model of memory. In addition, the activation of worry has been shown to increase intrusive cognitions, which interfere with attention, and may be particularly difficult to control or suppress in individuals with high levels of worry and/or GAD.

Given the theoretical properties ascribed to semantic networks, spreading activation and a high frequency of activating worry-related content in memory may result in the priming of worry related content in memory. This in turn may lead to a higher activation level and lower activation threshold for worry, and contribute to a self-maintaining cycle of worry activation. Further, considering that worry is associated with cognitive intrusions, uncontrollability at pathological levels, failed efforts at thought suppression, and attentional interference, pathological levels of worry may result in an activational cascade of worry-related content to the exclusion of other important cognitive content and/or processes. Partial evidence for this comes from the finding that priming worry results in impaired recall of emotional material (Lehtonen, et al., 2009). At normal levels, worry appears to involve the heightened activation of related content in memory.

Given the characteristics associated with worry listed above, worry serves as an ideal focus of investigations exploring mechanisms involved in a semantic network theory of mood. The identification of worry resulting in cognitive intrusions that are at times difficult to suppress, and findings that worry may interfere with attention suggests the possibility that processes that function to regulate such activities may underlie these effects. Consequently, inhibitory processes involved in motivated or automatic control of thoughts and attention in memory may play an important role. Further, if inhibitory processes do govern such activities, inhibitory dysfunction may serve as pathological

factor underlying the inability to suppress worrisome thoughts by individuals with GAD. As inhibitory processes function to suppress activation, decreased levels of inhibition may result in increased cognitive intrusions, and if inhibition is decreased to a dysfunctional level, the ability to suppress worry-related intrusions may be compromised, thus contributing to the pathological maintenance of worry.

INHIBITION, EMOTIONAL PROCESSING, AND WORRY

A number of explanations have been offered to account for findings supporting the proposition that worry suppresses the activation of fear and consequently interferes with emotional processing. First, worry might influence emotional processing via diffuse mechanisms such as attention. Support for this explanation comes from findings that attentional disruption is sufficient to negatively influence emotional processing (Grayson, Foa, & Steketee, 1982; Sartory, Rachman, & Grey, 1982; Kamphuis & Telch, 202000; Telch et al, 2004), and that worry disrupts attention (Borkovec et al., 1983; York et al., 1987; Pruzinsky & Borkovec, 1990). A second possibility is that worry may result in a cascade of worry-related activation in memory that imposes significant demands on cognitive resources. Consequently, worry may commandeer cognitive resources needed by other cognitive systems in general, and more specifically, cognitive resources within memory needed to activate fear structures. Thirdly, because activation of worry-related content in memory may be self-perpetuating and lower the activation threshold of worry-related content, such content may be the most readily retrievable information from memory. Positing that worry is a cognitive appraisal process, memory content related to threat appraisal rather than fear activation may be more strongly associated with worry. Consequently, a higher activation level and activation frequency of appraisal-related content may leave content involved in activating fear structures relatively less available

for memory activation and retrieval, resulting in less fear activation and emotional processing.

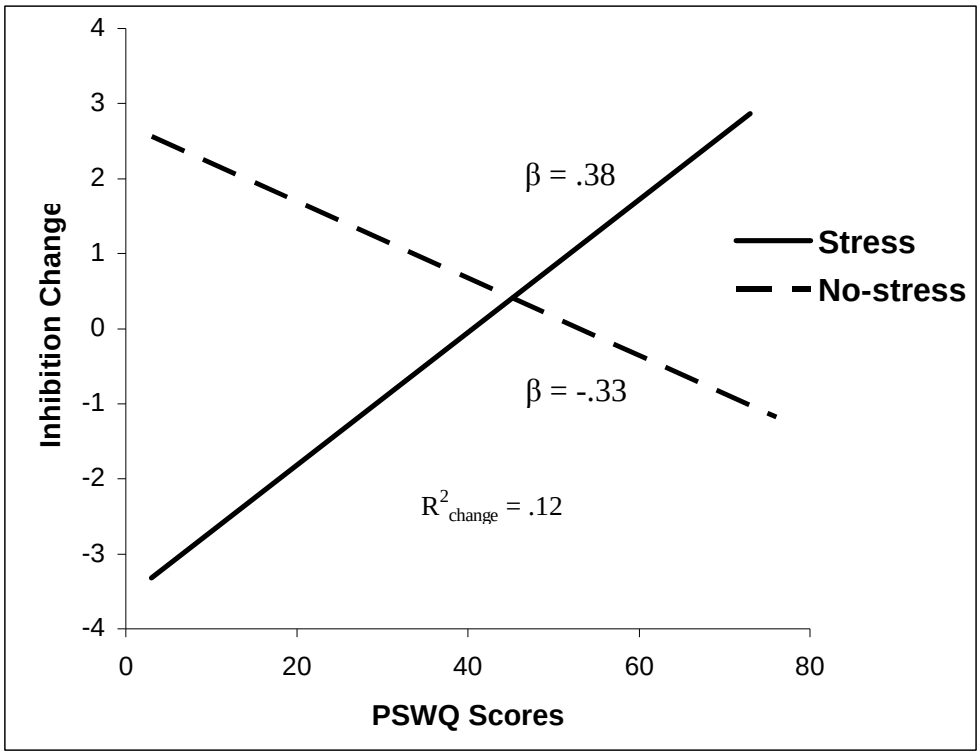
Another set of explanations derives from the identification of worry as primarily a verbal cognitive process. As presented in the section on worry and emotional processing, suppressed heart rate reactivity to fear stimuli following worry exposure has been restricted to worry involving verbal thought rather than mental imagery or affective focus (Borkovec, Lyonfields, Wiser, & Deihl, 1993). In general, verbalization is a less potent activator of fear than mental imagery.

Another possibility provides the primary basis for the proposed study. Worry may result in the activation of inhibitory processes in memory that suppress the activation of fearful propositions, decreasing fear activation and thus enabling the suspension of behavioral responding and enhancing cognitive appraisal and problem solving (Brown, et al., unpublished manuscript).

This proposition has received some support in a recent investigation of trait worry as a predictor of change in non-volitional inhibition following exposure to a potentially threatening situation (Brown et al., submitted manuscript). In this study, participants completed the retrieval practice paradigm prior to and following anxiety induction. Higher levels of trait worry as measured by the Penn State Worry Questionnaire (PSWQ; Meyer, et al., 1990) were found to predict increases in non-volitional inhibition in the anxiety induction condition, but decreases in the no-anxiety control condition (See figure 1 below). What makes these findings most interesting is the fact that measures of inhibition were obtained for neutral words, unrelated to either worry or anxiety. In another study, participants with GAD were found to be less able to intentionally forget threat information on a directed forgetting task (Albu, 2008). Taken together, findings

from these studies indicate that worry may be associated with increased inhibition of non-threat material and decreased inhibition of threat-related material in memory.

Figure 1: Change in Inhibition Measured by the RPP as a Function of Anxiety Induction and Trait Worry



The finding that trait worry predicts changes in the inhibition of material unrelated to worry when anxiety is present poses a number of interesting questions about how semantic stimuli characteristics may influence inhibition. It further raises questions about how inhibition may be influenced by the affective characteristics of stimuli as well as the semantic association of stimuli with worry. A number of possibilities regarding these issues exist. Inhibitory processes associated with worry may function primarily through semantic stimuli characteristics, primarily through affective stimuli characteristics, or similarly through both. Whichever the case, investigations of inhibitory processes associated with worry provide an excellent opportunity to greatly

increase current understanding of how inhibitory processes function in memory, and offers implications for understanding how semantic networks of memory and mood are organized. Further, investigating both volitional and non-volitional forms of inhibition in memory enables an understanding of how these processes may work, independently, in concert, or through one or the other to govern the activation of information in memory, as well as the processing of emotional information in particular.

Current Study Design and Hypotheses

EXPERIMENTAL GOALS AND DESIGN OVERVIEW

The current study was inspired by connections identified between semantic network theories of mood, emotional processing theory, and implications regarding the nature and functions of worry. The overall objective of this study was to better understand different kinds of inhibitory processes in memory as well as factors that may influence and/or interact with these processes. This study examined the relationship between different types of inhibition in memory and other cognitive processes including worry and thought suppression. It followed and expanded on previous findings that changes in verbal memory inhibition, in response to potential threat, are associated with trait worry (Brown et al., unpublished manuscript), and was specifically designed to pursue five main objectives:

1. Develop a greater understanding of normal variation in memory-based inhibition including the relationship between inhibition and individual difference factors such as efforts at thought suppression and trait worry.
2. Identify factors that influence inhibitory functioning in memory including identifying the manner of influence exerted by these factors. Specifically, to

identify the effects of induced worry, semantic association of stimuli to worry, and the affective valence of stimuli on inhibition in memory.

3. Investigate the possibility that inhibitory processes in memory may serve as a mechanism through which worry influences emotional processing.
4. Examine the relationship between different varieties of inhibition in memory, and test a model of mediation including volitional and non-volitional forms of inhibition. More specifically, to test the proposition that relationships between volitional inhibition in memory and other factors are mediated by non-volitional inhibition which may serve as a measure of inhibitory capacity.
5. Explored the viability of inhibitory functioning as:
    a. A process underlying efforts at thought suppression.
    b. A mechanism underlying both normal and pathological worry.

These study goals served as steps toward evaluating the potential for memory-based inhibitory functioning to serve as a pathogenic mechanism in the development and maintenance of pathological worry and GAD.

In order to achieve the study objectives, a 2 x 2 x 2 mixed-subjects design was employed to investigate moderator effects of trait worry and thought suppression for both volitional and non-volitional forms of inhibition under different stimulus and thought-induction conditions. Worry condition (worry induction vs. neutral thought) and affective valence (positive vs. negative affect words) served as between-subjects factors. Semantic association of word stimuli to spheres of worry (worry vs. non-worry categories) served as a within-subjects factor. Measures of volitional and non-volitional inhibition obtained with the DFT and RPP respectively served as the DVs. The development of the RPP and DFTs, capable of capturing inhibitory processes involved in

memory, provided an opportunity to directly examine the role of memory-based inhibition in emotional processes.

Repeated measures of non-volitional inhibition for worry and non-worry categories were obtained by repeated administrations of the RPP. Non-volitional inhibition, measured by each RPP, was calculated based on the differential free-recall percentage between non-practice words associated with and unassociated with the retrieval practice categories. Volitional inhibition measured with the DFT was calculated based on the differential free-recall percentage of to-be-remembered and to-be-forgotten words. Calculation of inhibition based on differences in percent free-recall provided equivalent scaling of inhibition measured in the RPP and DFT.

Measures of trait worry and thought suppression, obtained from the PSWQ (Meyer, et al., 1990) and White Bear Suppression Inventory (WBSI; Wegner & Zanakos, 1994) respectively, served as predictor variables. Measures of depressive symptoms obtained from the BDI served as a variable controlled for in the study. Measures of attention, subjective worry, and negative affect were collected in order to check the effectiveness of the thought induction manipulation.

HYPOTHESES

The primary hypotheses under investigation were predicted 4-way interactions between thought induction condition (worry vs. neutral thought), semantic association of word stimuli to domains of worry (associated vs. unassociated), affective valence of word stimuli (positive vs. negative), and the predictor variables of either trait worry or thought suppression on inhibition. The interaction of induction condition, semantic association of words with categories of worry, and affective valence of words were hypothesized to moderate the relationship between inhibition and the predictors of trait worry and thought

suppression. Specific predictions regarding nature of these interactions are presented in the following sections.

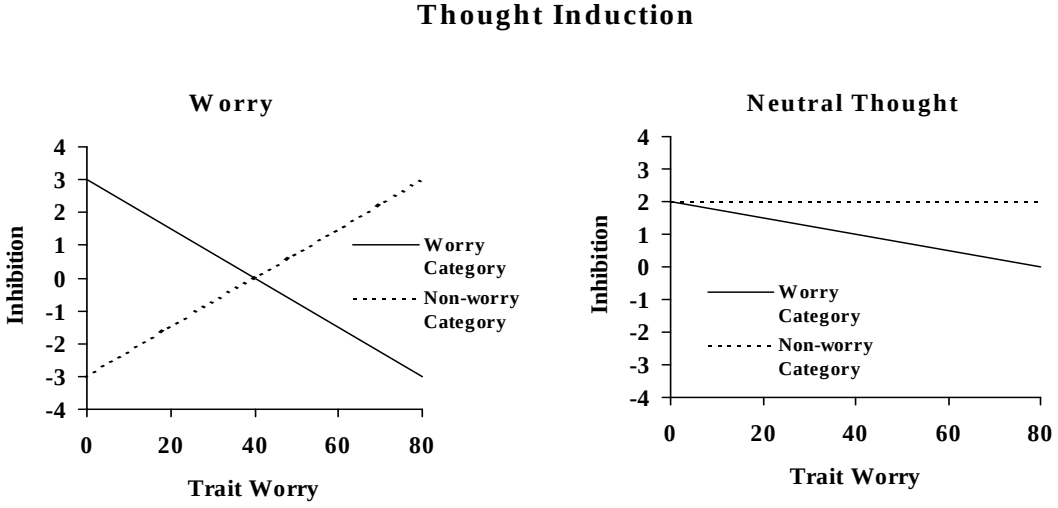
As measures of thought suppression have been found to positively correlate with measures of worry (Wegner & Zanakos, 1994), the hypothesized results for the relationship between thought suppression and inhibition mirror those hypothesized for measures of trait worry. The predicted relationships between worry and inhibition were not expected to differ based on the type of inhibition measured (volitional or non-volitional).

Trait Worry, Thought Induction, and Semantic Association

Hypotheses in this section explore an expected 3-way interaction between semantic association with worry (worry vs. non-worry category words), type of induced thought (worry vs. neutral) and trait worry on inhibition. Figure 2 provides a graphic depiction of the expected association between trait worry based on the semantic association of words with categories of worry and thought induction condition.

1. For words semantically associated with worry, it was expected that higher levels of trait worry would be associated with lower levels of inhibition, and that this relationship was expected to be stronger in the induced worry condition.
2. For words semantically unassociated with worry, it was expected that higher levels of trait worry would be associated with higher levels of inhibition, and that this relationship would only be present in the induced worry condition.

Figure 2: Hypothesized Interaction Between Type of Thought Induction, Semantic Category Association to Worry, and Trait Worry. Note: Hypothesized Regression Lines Presented in Each Figure.



Worry vs. Non-worry Semantic Category and Affective Valence

The following hypotheses expand on the 3-way interaction proposed thus far by including stimuli affective valence as an additional factor for consideration. With the inclusion of stimuli affective valence as a factor, a 4-way interaction was predicted such that word affective valence was expected to moderate the relationship between trait worry and inhibition under different conditions of induced thought and semantic association of words to worry categories.

1. In the absence of induced worry (neutral thought), the relationship between trait worry and inhibition based on semantic association of stimuli to worry was expected to differ depending on the affective valence of the stimuli.

a. For stimuli semantically unassociated with domains of worry, no relationship between trait worry and inhibition was expected based on the affective valence of stimuli. Because these words are semantically unassociated with worry, trait worry was not predicted to be associated with activation of these words in memory.
b. For stimuli semantically associated with worry, the relationship between trait worry and inhibition was expected to differ based on the affective valence of the word stimuli. This prediction drew on findings that higher levels of trait worry are associated with increased inhibition of neutral words that are semantically unassociated with worry following the induction of anxiety (Brown, Tucker, & Telch, unpublished manuscript). Thus, the relationship between trait worry and inhibition may be moderated by affective characteristics of stimuli even when the stimuli are all semantically associated with worry. Consequently, the following relationships were predicted.
    i. Higher levels of trait worry were expected to be associated with higher levels of inhibition for positive stimuli semantically associated with worry.
    ii. Higher levels of trait worry were expected to be associated with lower levels of inhibition for negative information semantically associated with worry.

2. When worry was induced, the relationship between trait worry and inhibition of words semantically associated with worry was expected to differ based on the affective valence of those words. Without this differentiation based on stimuli affective valence, it would be expected for higher levels of trait worry to be

associated with lower levels of inhibition. However, with the inclusion of stimuli affective valence as a factor, this relationship was expected to change based on positive or negative affective valence. Under this condition the following predictions were made.

i. Higher levels of trait worry were expected to be associated with higher levels of inhibition of positive affective stimuli.
ii. Higher levels of trait worry were expected to be associated with lower levels of inhibition of negative affective stimuli.

3. The strongest relationship between trait worry and inhibition was expected to occur for both negative and positive stimuli when worry was induced and the stimuli were semantically associated with worry.

Non-volitional Inhibition as a Mediator

It is possible that a non-volitional cognitive process may govern to some extent the capacity and limitations of the same cognitive process employed volitionally. In this case, non-volitional inhibition was expected to govern the extent to which volitional inhibition was enacted and thus mediate the relationship between volitional inhibition and other factors such as trait worry and thought suppression (see Figures 3 & 4). More specifically, if trait characteristics such as trait worry or thought suppression are associated with how someone is able to volitionally inhibit information in memory, this was expected work through non-volitional control of their inhibitory processes.

Figure 3: Model of Partial Mediation for Trait Worry

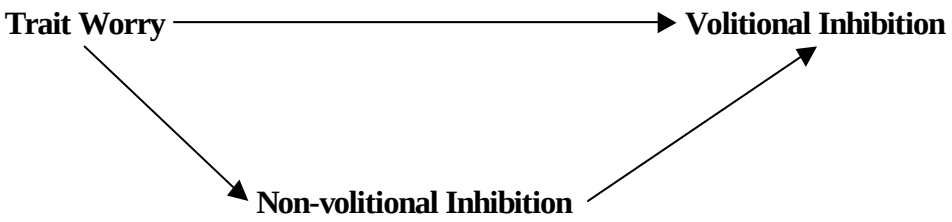


Figure 4: Model of Partial Mediation for Thought Suppression

METHODS

Participants

Participants included 86 undergraduate students (44 males & 42 females) enrolled in an introductory psychology course at the University of Texas at Austin. Participants were from varied ethnic backgrounds including 45 Caucasians, 20 Asian Americans, 15 Hispanic Americans, 2 African Americans, 1 Indian American, 1 Persian American, and 2 unknown resulting from participant objection to reporting there ethnicity. They ranged in age from 17 to 22-years old (M = 18.87, SD = .87). Of the 86 participants, 5 reported

having received a prior diagnosis of ADHD. No participants endorsed being on medication for depression or attention problems at the time of the study.

Involvement in this study satisfied part of the course requirement for research participation. A total of three participants who endorsed active suicidal ideation on the BDI were excluded from participation in order to minimize the risk to this group resulting from negative mood effects associated with worry induction. No compensation was provided for participation. All participants were treated in accordance with ethical standards for the treatment of human subjects in research.

Materials

QUESTIONNAIRES

Worry

Trait Worry

Trait worry was assessed by self-report with the Penn State Worry Questionnaire (PSWQ; Meyer, et al., 1990). The PSWQ is a 16-item questionnaire that assesses trait worry based on the quantity and controllability of worry (see Appendix B1). Each item is rated on a 1-5 point scale (1= not at all typical & 5 = very typical), and 5 of the 16 PSWQ items are reverse scored. The PSWQ has demonstrated high internal consistency (α = .93), excellent test-retest reliability (r = .92), and good discriminant validity in detecting GAD among college students (Meyer, et al., 1990). An investigation of the psychometric properties of the PSWQ in a clinical population (Brown, Antony, & Barlow, 1992) found that the mean score on the PSWQ for individuals meeting diagnostic criteria for GAD is 68.11 with a standard deviation of 9.59. The mean score for individuals who do not meet

diagnostic criteria for any DSM-IV (APA, 1994) anxiety disorder is 34.90 with a standard deviation of 10.98.

Idiopathic Worry Domains

Idiopathic domains of worry used for worry induction were assessed with the Student Worry Questionnaire (SWQ; Osman, Gutierrez, Downs, Koppler, Barrios, & Haraburda, 2001). The SWQ is a 30-item subjective self-report measure of 6 worry domains for a student population (see Appendix B2). The six domains of worry assessed by the SWQ include worrisome thinking, financial related concerns, significant others' well being, social adequacy concerns, academic concerns, and general anxiety symptoms. Items on the SWQ are rated on a zero to four Likert scale representing how characteristic the statement of the individual (0 = Almost Never characteristic of me & 4 = Almost Always characteristic of me). The SWQ has demonstrated high internal consistency (α = .94) and good test-retest reliability (r = .86). The SWQ has also demonstrated adequate convergent validity with the PSWQ (r = .76) and the State Trait Anxiety Inventory-Trait version (r = .64; Spielberger, Gorsuch, & Lushene, 1970).

Thought Suppression

The White Bear Suppression Inventory (WBSI; Wegner & Zanakos, 1994) was used to obtain measures of thought control characterized by efforts to suppress thoughts. The WBSI is a 15-item self-report measure of efforts to avoid unwanted thoughts (see Appendix B3). Each item on the WBSI is rated on a 5-point scale from 1 (strongly disagree) to 5 (strongly agree). It has demonstrated good internal consistency ranging from α = .87 to .89 in different samples. The test-retest reliability of the WBSI was demonstrated to be excellent over a 1-week period (r = .92) and acceptable over a 3-month period (r = .69). An association between the WBSI and measures of OCD,

depression, state anxiety, anxiety sensitivity, and GAD has also been demonstrated (Wegner & Zanakos, 1994; McKay & Greensberg, 2002).

Depression

The Beck Depression Inventory-II (BDI-II; Beck, Steer, & Brown, 1996) was used in order to measure current symptoms of depression. The BDI-II is a 21-item self-report measure assessing severity of depression including a cognitive-affective dimension and a somatic-vegetative symptom dimension (Dozois, Dobson, & Ahnberg, 1998). Each item on the BDI-II is rated on a 4-point scale (0-3) based on 4 statements that represent successively increasing symptom severity and correspond to the increasing scale numbers. The BDI-II has demonstrated good internal consistency (α = .89 - .91) in two college samples (Steer & Clark, 1997; Dozois et al., 1998). The BDI-II has demonstrated convergent validity with the earlier version (BDI) and been shown do demonstrate some clinical utility in differentiating between depressed and non-depressed college students (Dozois et al., 1998).

Generalized Anxiety Disorder

Initial screening for GAD diagnoses was conducted using the GADQ-IV (Newman, Zuellig, Kachin, Constantino, Przeworski, & Erickson, 2002). The GADQ – IV (see Appendix B4) is a self-report diagnostic measure of GAD based on DSM-IV diagnostic criteria for GAD (APA, 1994). It consists of relevant diagnostic questions related to the experience of uncontrollable and excessive worry, the occurrence of uncontrollable and excessive worry for the past six months, the degree to which worry interferes with normal functioning, and the presence of three out of six associated symptom groups. In a preliminary investigation with a group of 142 undergraduate students, 90 of whom were interested in obtaining diagnoses, including non anxious

controls, and participants with social phobia, GAD, or panic disorder, the GADQ-IV identified 30 cases of GAD as a primary or secondary diagnosis (Newman, et al., 2002). In this sample, the GADQ-IV was shown to have 89% specificity and 83% sensitivity in diagnosing GAD. It has also demonstrated adequate test-retest reliability, and convergent and discriminant validity. It has further been shown to have agreement with a structured diagnostic interview comparable to the agreement between two raters using the same structured interview.

Trait Anxiety

Trait anxiety was measured using the STAI-T (Spielberger, et al., 1970). The STAI-T is a measure of trait anxiety that asks participants to rate how they feel in general for each of 20 items that represent positive and negative feelings on a four-point Likert-type scale (1 = almost never and 4 = almost always). Trait anxiety is posited to represent an individual's tendency to perceive potential threat in the environment. The STAI-T has demonstrated high internal consistency, reported around 0.90 (Spielberger, et al., 1970).

CLINICAL ASSESSMENT

Structured Diagnostic Interview: GAD

Composite International Diagnostic Interview (CIDI-2.1)

Follow-up assessment of GAD status for individuals meeting clinical criteria on the GADQ-IV was conducted with the CIDI-2.1. The CIDI-2.1 is a fully structured interview available in a computerized version that allows for administration by interviewer and scoring by computer algorithms. Owing to time constraints dictated by the experimental focus of the proposed study, only the GAD section of the anxiety disorders module from the CIDI-2.1 was used.

The CIDI-1.0 was developed through the Joint Project on Diagnosis and Classification of Mental Health Disorders in Alcohol and Drug-Related Problems under the rubric of the World Health Organization (WHO) and the former Alcohol, Drug Abuse, and Mental Health Administration (ADAMHA). The CIDI-1.0 was designed as a multicultural, fully standardized and comprehensive diagnostic interview for mental disorders based on the ICD-10 (WHO, 1991) and DSM-III-R (APA, 1987) criteria. Changes in DSM criteria resulting from the introduction of DSM- IV (APA, 1994) have resulted in revisions of the CIDI-1.0 and subsequent development of the CIDI-2.1. As initial development of the CIDI-1.0 was based on earlier diagnostic systems, most of the psychometric information available derives from investigations comparing this earlier version with the earlier DSM-III-R diagnostic system (Witchen, Robins, Cottler, Sartorius, Burke, & Regier, 1991; Wittchen, 1994; Peters & Andrews, 1995; Wittchen, Kessler, Zhao, & Abelson, 1995; Wittchen, Zhao, Abelson, Abelson, & Kessler, 1996).

Even though these studies provide psychometric evidence based on antiquated diagnostic criteria, a number of these studies have specifically examined the utility of the CIDI-1.0 for diagnosing anxiety disorders, an issue of particular relevance for the proposed study. One such study (Wittchen et al, 1995) investigated the test-retest reliability and clinical validity of a modified version of the CIDI-1.0 (UM-CIDI) for the diagnosis of GAD. The findings reveal adequate test-retest reliability given retest occurred at a 19-26 month follow-up. However, while concordance rates between the UM-CIDI and the Structured Clinical Interview for DSM-III-R (SCID) were lower than expected, the disagreement between these instruments appeared to be isolated to a specific criterion no longer employed in currently diagnosing GAD. Once this criterion was removed, concordance between the instruments substantially improved (Wittchen et al., 1995).

The CIDI-2.1 was developed in order to incorporate revisions in diagnostic criteria and changes recommended based on the functional characteristics of the CIDI-1.0 (Andrews & Peters, 1998). While no identified studies have investigated the reliability and validity of the CIDI-2.1 based on DSM-IV diagnostic, the goal of developing an improved version of the CIDI based on years of experience with the CIDI-1.0 is likely to yield enhanced psychometric properties incorporated into the CIDI-2.1 (Andrews & Peterson, 1998)

The CIDI-2.1 and the GADQ-IV were used in conjunction to enhance the accuracy of GAD diagnostic assessment. The administration of only the GAD of the CIDI-2.1 section was employed to circumvent the practical limitations associated with the administration of a lengthy structure diagnostic interview.

Attention Deficit Hyperactivity Disorder (ADHD)

Past or current diagnosis of ADHD was assessed based on participant self-report responses to a question asking participants if they had ever been diagnosed with attention problems.

MEASURES

Subjective Units of Worry

The percent of thought attributed to worrying was assessed by subjective self-report on a 0 to 100% scale. In addition, subjective worry severity was assessed by self-report, using an 11-point Likert scale (0 = not worried at all, 5 = moderately worried, & 10 = extremely worried).

Affect

Current negative affective state was measured with the negative scale of the Positive and Negative Affect Schedule (PANAS; Watson, Clark, and Tellegen, 1988).

The PANAS consists of subjective self-report ratings of positive and negative affect for 10 positive and 10 negative descriptors relating to current affect (e.g. jittery or proud). Negative affect scores were calculated by summing ratings for each of the 10 negative affect items. The PANAS was developed in order to provide an easy to use, self-report measure of two affective domains, positive and negative affect. Basic psychometric data for the PANAS was collected primarily from undergraduate university students and adult university employees (Watson, Clark, and Tellegen, 1988). The PANAS has demonstrated good internal consistency within an undergraduate university student sample, and has been found to distinguish differences in negative affect between students and a psychiatric inpatient sample (α = .84 - .90, Watson, Clark, and Tellegen, 1988). The PANAS has demonstrated convergent validity with the BDI (Beck et al., 1961) State-Trait Anxiety Scale-Anxiety State version (Spielberger, Gorsuch, & Lushene, 1970).

Attention

Measures of attention were obtained through administration of a serial addition continuous performance task (SACPT). The SACPT was developed and piloted with the goal of utilizing an attention test that would be sensitive enough to detect variation in attention among a college student sample. The SACPT serially presented 310 single digit numbers for 600 milliseconds each with inter-stimulus intervals of 1.85 sec. Following the presentation of each number, the participant was required to respond if the number just presented would result in an odd number when added to the previous number they were shown. They were not to respond if the sum of the numbers resulted in an even number. This procedure allowed for the recording of reaction time (recorded in ms.), variability of reaction time, errors of commission, and errors of omission. The SACPT presentations were constructed and presented with Presentation® software (Version 0.76,

www.neurobs.com). Reaction time and error data were recorded by the presentation program.

Volitional and Non-volitional Inhibition

Non-volitional inhibition measured with the RPP (Anderson et al., 1994; Anderson & Spellman, 1995) was calculated by subtracting the percent free-recall of associated non-practiced words (ANPW) from the percent free-recall of non-practiced words (NPW). Volitional inhibition was measured with the directed forgetting task (DFT). Measures of volitional inhibition were calculated by subtracting the percent free-recall of to-be- forgotten words from the percent-free recall of to-be-remembered words.

INTERCOM SYSTEM

A Westinghouse 2-channel wireless intercom system was used to communicate with participants isolated in a separate lab room during the thought induction sessions. This enabled the experimenter to communicate with the participant, but prevented contamination of neutral thought induction by potential activation of social-evaluative concerns had the experimenter remained present during the thought induction session.

INHIBITION PARADIGMS

Stimuli Generation

Word stimuli for the RPP and DFT were generated through a web-based pilot study (see Appendix A) with three objectives: 1) Obtain a list of positive and negative affect words for four worry and four non-worry categories to be used in the RPP. 2) Obtain a list of positive and negative affect words for use in the DFT, both highly related and unrelated to worry, but that do not fall within the four worry and non-worry categories to be used in the RPP. 3) Collect normative ratings for characteristics of each

word including affective valence, strength of association with worry, imageability, category association strength, and concreteness.

The Retrieval Practice Paradigm

Stimulus Lists

This study employed four modified versions of the original RPP (Anderson et al., 1994; Anderson & Spellman, 1995) including worry categories with negative words, worry categories with positive words, non-worry categories with negative words, and non-worry categories with positive words. Stimuli in the RPP were classified based on assignment of categories to undergo retrieval practice (RPC) or categories that did not undergo retrieval practice (NPC). Further division of words in the RPC resulted in only half of the RPC words receiving retrieval practice. This yielded three different classifications of words in the RPP including words from RPC that undergo retrieval practice (RPW), RPC words that share category association but do not undergo retrieval practice (ANPW), and words from the NPC that are neither associated with RPC words nor undergo retrieval practice (NPW).

Each RPP included 4 experimental categories with 10 words in each (number of words = 40), and 2 filler categories with 6 words in each (number of words = 12). In order to maintain consistency in functional word characteristics, only nouns were used for RPP stimuli. Further each category word set was equated based on ratings of imageability and category association strength obtained through the pilot study described in Appendix A.

Categories in each RPP version were randomly assigned to either RPC or NPC, and half of the RPC words were randomly assigned to either ANPW or NPW. This left two categories and half of the RPC words unexposed to retrieval practice. In order to

ensure that all categories and words receive retrieval practice, three additional versions of each RPP were created.

Presentation Development

The RPP presentations were constructed and presented with Presentation® software (Version 0.76, www.neurobs.com). Presentation (Version 0.76) uses a derivation of C++ and Java programming language to construct presentation scenarios, trials and stimulus events. The development of presentation scenarios for the RPP corresponded with four presentation phases: a learning phase, a retrieval practice phase, a delay/distraction phase, and a free-recall test phase. All word stimuli in the RPP were presented in Arial 40 pt font.

The ordering of categories for the learning phase were determined using block randomization procedures, resulting in 10 block presentations of the four categories. Word order was randomized for each category independently. In order to control for primacy and recency effects, six category-word pairs from filler categories were included at the beginning and end of the learning phase. In the learning phase presentation, each category word pair was presented one time for category associate learning. The presentation of each category word pair was set to transition every 3 sec.

Retrieval practice was conducted using a category stem-cue format. Each practice category was presented with the two-letter stem cue for the respective retrieval practice word (RPW). Stimuli in the retrieval practice phase were constructed to accomplish two goals: to pair each of the 10 RPWs with its respective category for presentation three times, and to provide a conditional branching framework that ensures successful retrieval practice of all RPWs. The ordering of category-exemplar pairs were determined by block randomization, resulting in a single presentation of each of 10 category-exemplar pairs within each of 3 blocks. In order to control for primacy effects, recency effects, and

spacing between repetitions of experimental category-word pairs, category-word pairs from filler categories were included at the beginning and end of the list, and after every three experimental category-exemplar pairs.

The SACPT was presented during the delay/distraction phase. This served, to provide a recall delay period with a non-verbal stimulus distraction task that would prevent rehearsal.

The free-recall phase involved the category prompted recall of all words learned in each category during the learning phase of the RPP. Each of the four experimental and two filler categories were presented on screen for 30 sec., during which written free recall of all of the words learned in each category is recorded. The experimental categories were randomly ordered for presentation, and a filler category was presented before and after the experimental categories.

The Directed Forgetting Task

Stimulus Lists

The DFT was constructed to enable a within task manipulation of stimuli association to worry (worry vs. non worry related words). Words used in the DFT were rated as highly associated with worry, but weakly or not associated with one of the worry categories used in the RPP. Two different versions of the DFT were developed based on affective valence (positive or negative) of word stimuli.

Each DFT consisted of 60 words including 48 experimental and 12 buffer words, divided into two word lists with 24 experimental and 6 buffer words each. Half of the experimental and buffer words were randomly assigned to each list, resulting in each list containing 12 worry and 12 non-worry related words.

Presentation

The DFT presentations were constructed and presented with Presentation® software (Version 0.76, www.neurobs.com). Words in each list were randomly ordered for presentation, and 3 buffer words were presented at the beginning and end of each list to control for primacy and recency effects. Each word in the DFT was presented for 1 sec., in Arial 40 pt. font, followed by a blank screen appearing for one second until the next word is presented. In the beginning of the DFT, one of the lists was presented for learning on the basis that recall of the words on the list would be tested at the end of the task. Following presentation of the first list, on screen instructions were provided to either forget the words just presented, because they would not actually be on the test, or to remember the words because they would be on the test. Following, these instructions, the second list was presented, followed by similar forget or remember instructions. In each DFT presentation, one list was followed by forget instructions and the other list was followed by remember instructions. In order to control for list effects, assignment of each list as to-be-forgotten or to-be-remembered was counterbalanced. To control for order effects, the order of forget or remember instructions following the first list presentation or the second list presentation was counterbalanced. The SACPT was administered during the delay/distraction phase of the DFT. Following the SACPT administration, DFT free-recall of all words, both remember and forget words were recorded by written response.

Design

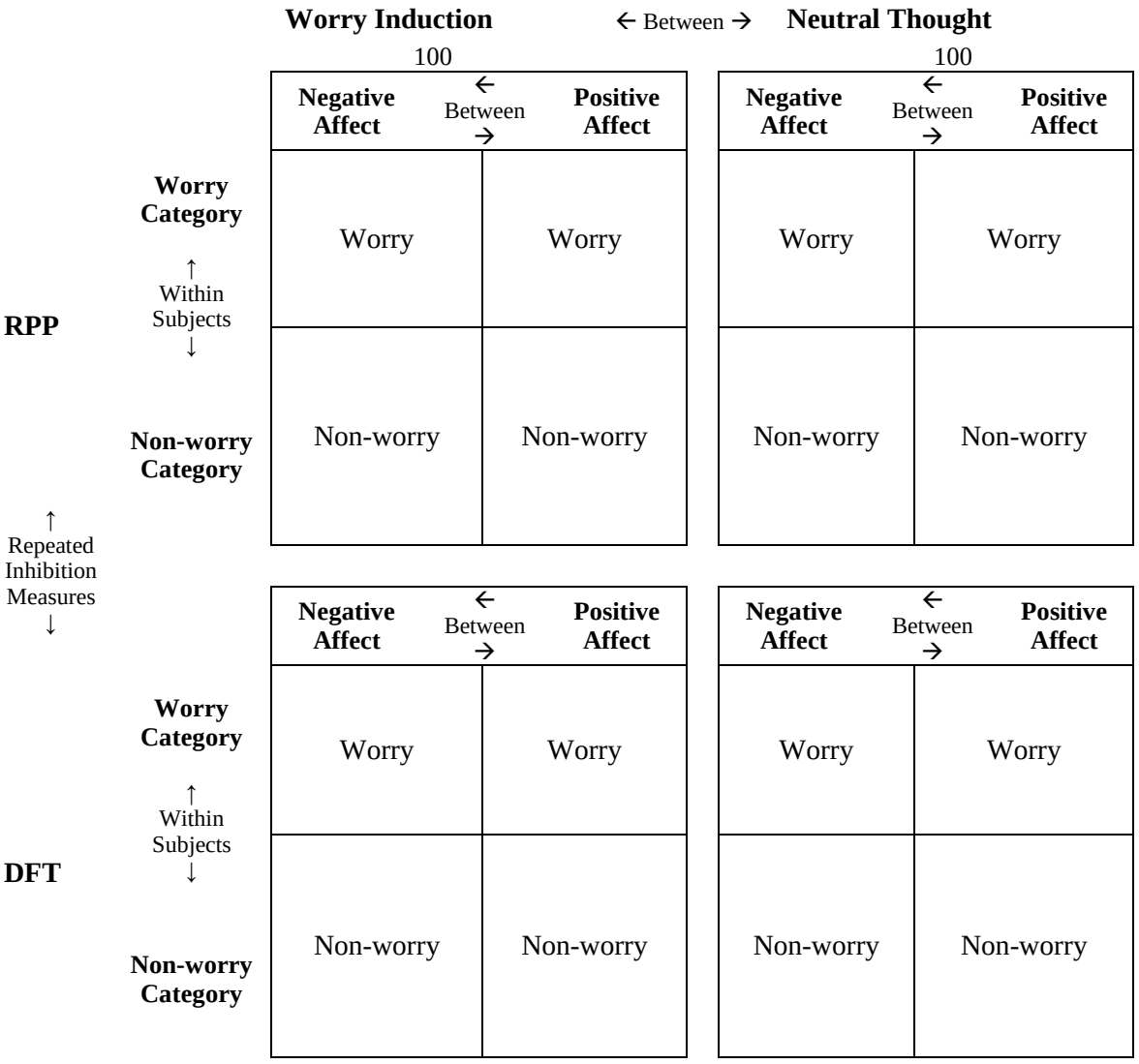
This study employed a 2 (induced worry vs. neutral thought) x 2 (negative vs. positive affect words) x 2 (words semantically associated vs. unassociated with worry) mixed-subjects design strategy to investigate the differential effects of induced worry, semantic stimuli characteristics, and word affective valance on inhibition of words in

memory. Figure 5 below provides a graphic depiction of the general design strategy. Worry condition (worry induction vs. neutral thought) and affective valence (positive vs. negative affect words) served as between-subjects factors. Semantic category (worry vs. non-worry) served as within-subjects factors. Two different measures of inhibition (volitional vs. non-volitional), obtained with the DFT and RPP respectively, served as the DVs.

In order to investigate the hypotheses that trait worry and thought suppression serve as moderators of inhibitory functioning depending on the different experimental conditions outlined, they were included as predictor variables in the design. In order to investigate inhibitory differences between pathological and non-pathological worry under the different design conditions, an additional between-subjects factor with three levels (high-worry with and without GAD and low worry) was incorporated into the design. Clinical GAD status was determined based on responses from the GADQ-IV and follow-up diagnostic assessment with the CIDI-2.1.

Repeated measures of non-volitional inhibition were obtained by repeated administrations of the RPP. Non-volitional inhibition measured by the RPP was calculated based on the differential free-recall percentage between non-practice words associated with and unassociated with the retrieval practice categories. Volitional inhibition measured with the DFT was calculated based on the differential free-recall percentage of to-be-remembered and to-be-forgotten words. Calculation of inhibition based on differences in percent free-recall provides equivalent scaling of inhibition measured in the RPP and DFT.

Figure 5: General Design Strategy Layout Including the RPP and DFT Represented as Repeated Measures of Inhibition with Thought Induction and Word Affective Valence as Manipulated Factors



Measures of trait worry and thought suppression were based on scores obtained from the PSWQ and WBSI respectively. Measures of attention and depressive symptoms served as individual difference variables that were controlled for. Attention was

measured based on the number of errors of omission and variations in reaction time obtained with the serial addition continuous performance task. Depressive symptoms were measured by scores on the BDI.

An affective state score was calculated based on rating scores provided on the PANAS. SUW recorded at several intervals were used to ensure maintenance of worry over the duration of the experiment. Measures of attention were obtained with the SACPT at baseline and during the delay phase of each RPP and the DFT administration. This allowed for repeated measures of change in attention over the duration of the experiment. It also allowed for a comparison of differences in attention based on participant assignment to the worry or non-worry thought condition as worry has been shown to interfere with attention. Disruption of attention provides an indirect measure of intrusive thoughts believed to contribute to the maintenance of worry.

Procedure

QUESTIONNAIRES AND ASSESSMENT

Each questionnaire packet included the PSWQ, SWQ, GADQ-IV, WBSI, and BDI. The order of questionnaires was randomly determined for each packet. Diagnostic assessment of GAD was conducted with the GADQ-IV and CIDI-2.1. Only individuals with a higher likelihood of meeting GAD diagnostic criteria on the GAD-IV were administered the CIDI-2.1. Past or current ADHD was assessed with a single question assessing whether or not the participant has ever been diagnosed as having attention problems, past or current. Demographic information including age, gender, and ethnicity was collected. In addition, self-reported high school and current GPA, and SAT scores were collected as measures of academic achievement and proxy measures of intellectual ability. Lastly, diagnostic history including current or past major depression, current or

past ADHD, and current medication use were obtained through a brief screening interview.

WORRY AND NEUTRAL THOUGHT INDUCTION

Participants were administered either an idiopathic worry induction or neutral thought induction based on their assignment to condition. In order to avoid the potential confound of activating social evaluative concerns arising from the experimenters' presence during the neutral thought induction, participants were left alone in a room, in a comfortable chair during all thought induction sessions.

In the worry induction condition, the participant was escorted to the induction room and the experimenter spent a brief period with the participant in order to identify their greatest area of worry. This was assessed based on items endorsed highest on the SWQ-30. The participant was asked which of the areas endorsed constituted the most worry for them, and whether there was another area, not addressed by the questionnaire that they worried about more. Once identified, the participant was asked to sit alone in the induction room and worry about that topic intensely and in their usual manner until asked to stop.

In the neutral thought procedure, participants were asked to choose a topic they felt neutral about, which provided the focus of their thought for the neutral thought induction. Examples included activities such as camping, watching television, reading, or eating a meal, etc.

Induction boosters were administered prior to each subsequent RPP or the DFT. Participants were asked to repeat the same thought procedure they had engaged in before.

EXPERIMENTAL PROTOCOL AND DATA COLLECTION

Participants were randomly assigned to one of four conditions based on thought induction (worry vs. neutral thought) and affective valence of the word stimuli (positive vs. negative) for the RPPs and DFT. All participants were administered the DFT and received two administrations of the RPP; one constructed with worry categories and one with non-worry categories. Both worry and non-worry words were used in the DFT, which provided repeated measure of volitional inhibition of both worry and non-worry words. In order to control for possible carryover effects, three possible order combinations were used based on repeated RPP administration and the single DFT administration. These orders differed based on ordinal position of the DFT, before the first RPP, between the first and second RPP, or after the second RPP. Table 1 presented below provides a graphic depiction of each order.

After undergoing informed consent, participants completed a questionnaire packet including the PSWQ, SWQ-30, GADQ-IV, WBSI, and BDI-II and underwent a brief screening interview to collect data on demographics, academic performance, current and past diagnostic history of depression and/or ADHD, and current medication information. Participants who met GAD criteria on the GADQ were interviewed with the GAD section of the CIDI-2.1 anxiety module. The experimenter administered the CIDI-2.1 through a brief interview, and participant responses were manually recorded for later scoring.

Table 1 Table of RPP and DFT Counterbalanced Administration Orders

Order #1

		Thought Induction							
		Worry				Neutral Thought			
		RPP Categories				RPP Categories			
1st RPP		Worry		Non-worry		Worry		Non-worry	
	Affective Valence	+	-	+	-	+	-	+	-
2nd RPP		Non-worry		Worry		Non-worry		Non-worry	
	Affective Valence	+	-	+	-	+	-	+	-
DFT	Affective Valence	+	-	+	-	+	-	+	-

Order #2

		Thought Induction							
		Worry				Neutral Thought			
		RPP Categories				RPP Categories			
1st RPP		Worry		Non-worry		Worry		Non-worry	
	Affective Valence	+	-	+	-	+	-	+	-
DFT	Affective Valence	+	-	+	-	+	-	+	-
2nd RPP		Non-worry		Worry		Non-worry		Non-worry	
	Affective Valence	+	-	+	-	+	-	+	-

Order #3

		Thought Induction							
		Worry				Neutral Thought			
DFT	Affective Valence	+	-	+	-	+	-	+	-
		RPP Categories				RPP Categories			
1st RPP		Worry		Non-worry		Worry		Non-worry	
	Affective Valence	+	-	+	-	+	-	+	-
2nd RPP		Non-worry		Worry		Non-worry		Non-worry	
	Affective Valence	+	-	+	-	+	-	+	-

Upon completion of the questionnaires and assessment interview, participants were instructed in how to wear the heart rate monitor, and recording of hear rate began. An event marker was entered into the heart rate monitor at the beginning and end of each task. After heart rate monitoring was started, participants were taken to another room for isolation where they were administered instructions for either neutral or worry thought

induction. The experimenter obtained worry ratings from participants at the beginning and end of each induction session via intercom. Upon completion of thought induction, participants provided self-report ratings of subjective worry (SWU) and affect (PANAS), These ratings were also obtained following each subsequent booster induction. Participants were then administered the first RPP, the DFT, and the second RPP. Instructions for participants at each stage of the RPP are provided in Appendix C1, and instructions for participants at each stage of the DFT are provided in Appendix C2. Following each task, participants received a 5 min. induction booster session. Each experimental administration was estimated to take approximately 2-hrs. Upon completion, participants were debriefed and thanked for their assistance. Participants who demonstrated a marked increase in negative affect were contacted the next day to confirm the transient nature of these negative mood effects and to provide them with assistance where necessary. This only occurred twice over the course of the experiment, and follow up assessment resulted in participants reporting they had returned to baseline levels of affect within 30 min. of leaving the experiment room.

Statistical Analyses

ANCOVAs Testing Trait Worry and Thought Suppression Predictors

The analyses for all experimental hypotheses relating to trait worry, worry induction, category association with worry, and affective valence of word stimuli were analyzed in a 2 x 2 x 2 repeated measures ANCOVA with trait worry entered as a continuous variable. An a priori alpha of .05 was set. Repeated measures of volitional and non-volitional inhibition were entered from scores obtained by the DFT and RPPs respectively. Within-participants repeated measures of inhibition of words semantically associated and unassociated with worry categories were entered based on measures from

the repeated RPPs and the DFT. Type of thought induction (worry or neutral), and affective word valence (positive or negative) were entered as between-participants factors. Trait worry measured by the PSWQ was entered as a covariate. Current level of depressive symptoms, measured with the BDI-II was entered as a covariate to control for the effects of depression on inhibition.

Simple-effects comparisons were determined by results from the initial ANCOVA, and used to investigate hypotheses relating to specific interaction effects. Follow-up ANCOVAs and multiple regression analyses were conducted to investigate interaction effects in the model and identify simple-effects.

This same analytic strategy was repeated for thought suppression scores obtained with the WBSI. In this case, trait worry was removed as a covariate, and thought suppression was entered in its place.

Due to an insufficient number of participants meeting the GAD diagnostic criteria (n = 0) required by the GAD-Q and the CIDI 2.1, analyses investigating differences between individuals meeting criteria for GAD and non-clinical controls had to be abandoned.

TESTS OF MEDIATION

In order to test the hypotheses that the relationship between trait worry or thought suppression and volitional inhibition would be partially mediated by non-volitional inhibition, tests of mediation were conducted using regression analyses. Tests of mediation were conducted for the experimental conditions where a relationship between either trait worry or thought suppression and volitional inhibition were identified. These analyses followed the guidelines proposed by the MacArthur approach (Kraemer, Kiernan, Essex, & Kupfer, 2008; Makinnon, 2008) for testing mediation. The MacArthur approach requires two necessary, but not sufficient criteria be met for a potential

mediator. First, that the predictor temporally precedes the mediator. This must be empirically established. Second, the predictor and the mediator must be significantly correlated. Given the study design, temporal precedence of the predictor over the mediator could not be established observationally. However, the goal of these analyses were to test the potential of non-volitional inhibition to serve as a mediator between trait worry or thought suppression and volitional inhibition. Consequently, establishing it as meeting other correlational criteria is an advance forward in its consideration as a potential mediator.

The analytic strategy set forth in the MacArthur approach (Kraemer, Kiernan, Essex, & Kupfer, 2008, Makinnon, 2008) was followed with volitional inhibition serving as the criterion variable, either trait worry or thought suppression serving as predictors, and non-volitional inhibition serving as the potential mediator. In step one, the correlation between predictor and outcome variable (trait worry or thought suppression and volitional inhibition) was calculated. In step two, the correlation between the predictor and the mediator (trait worry or thought suppression and non-volitional inhibition) was calculated. In the last step linear regression was conducted with trait worry or thought suppression entered as predictors, non-volitional inhibition entered as the mediator, and volitional inhibition entered as the criterion variable. Correlationa criteria for partial mediation would be confirmed if a significant amount of shared variance in volitional inhibition was accounted for by non-volitional inhibition in the model when the predictors of either trait worry or thought suppression were also included in the model.

RESULTS

Descriptive Statistics

This section presents descriptive data for the study sample, intercorrelations of measures, and means and standard deviations of inhibition measures by factor. No significant group differences or interaction were found for academic performance measures based on thought induction or stimuli affective valence. Table 2 provides means and standard deviations of academic data for the sample by thought induction and stimuli affective valence conditions. No significant group differences or interaction were found for individual difference measures based on thought induction or stimuli affective valence. Table 3 provides means and standard deviations of individual difference measures including measure of anxiety, worry, thought suppression and depression based on assignment to stimuli affective valence and thought induction conditions.

Table 2 Table of Means and Standard Deviations of Participants Self-reported Academic Performance by Thought Induction and Word Affective Valence Conditions

Affective Valence	Thought Induction Condition					
	Worry Induction			Neutral Thought		
Negative Affect Words	*n*	*M*	*SD*	*n*	*M*	*SD*
High School GPA	22	3.90	.519	18	3.98	.518
College GPA	18	3.48	.473	11	3.17	.585
SAT Scores	22	1294.55	174.89	16	1321.25	112.72
	Worry Induction			Neutral Thought		
Positive Affect Words	*n*	*M*	*SD*	*n*	*M*	*SD*
High School GPA	24	3.91	.408	21	3.84	.480
College GPA	20	3.22	.618	13	3.32	.648
SAT Scores	24	1268.33	125.20	20	1233.50	147.23

Table 3 Table of Means and Standard Deviations of Individual Difference Factors by Thought Induction and Word Affective Valence Conditions

Affective Valence	Thought Induction Condition			
	Worry Induction (n = 22)		Neutral Thought (n = 18)	
Negative Affect Words	*M*	*SD*	*M*	*SD*
State-Trait Anxiety Inventory-Trait Version	39.09	9.56	35.11	9.24
Penn State Worry Questionnaire	44.50	11.69	46.56	11.89
Student Worry Questionnaire-30	46.55	19.81	45.22	24.86
White Bear Suppression Inventory	44.91	11.63	44.33	12.54
Beck Depression Inventory-II	6.95	4.88	6.89	5.22
	Worry Induction (n = 25)		Neutral Thought (n = 21)	
Positive Affect Words	*M*	*SD*	*M*	*SD*
State-Trait Anxiety Inventory-Trait Version	38.92	8.65	37.00	6.35
Penn State Worry Questionnaire	46.76	13.84	47.76	13.93
Student Worry Questionnaire-30	52.84	20.66	51.57	17.51
White Bear Suppression Inventory	46.56	11.31	48.24	8.92
Beck Depression Inventory-II	7.68	4.63	6.38	3.25

No significant correlations with measures of inhibition were found between any individual difference measure, academic performance measure, or baseline assessment of

worry. Table 4 provides correlations between measures of inhibition and measures of individual differences, academic performance, and baseline worry.

Table 4 Table of r Values for Correlations of Individual Difference Measures, Academic Performance, and Baseline Assessment Measures with Inhibition Measures

	Inhibition Measures			
	Volitional Inhibition (DFT)		Non-volitional Inhibition (RPP)	
Individual Difference Measures	Worry Associated	Worry Unassociated	Worry Associated	Worry Unassociated
State-Trait Anxiety Inventory-Trait Version	.136	.077	-.073	.053
Penn State Worry Questionnaire	.189	.085	-.130	.151
Student Worry Questionnaire-30	.159	.053	.048	.198
White Bear Suppression Inventory	.031	.022	.050	.116
Beck Depression Inventory-II	.160	.106	-.067	.028
Academic Performance				
High School GPA (n = 85)	.024	.135	-.045	.015
College GPA (n = 62)	-.167	.135	-.180	.202
SAT Score (n = 82)	-.008	-.094	-.089	.045
Baseline Assessment				
Subjective Units of Worry	.016	-.193	.049	-.008
Percentage of Worry Thought Reported	.044	-.167	-.027	.003

Worry Induction Manipulation check

SUBJECTIVE UNITS OF WORRY AND PERCENTAGE OF WORRY THOUGHT CONTENT

In order to provide a check for the effectiveness of the worry induction procedure, subjective units of worry (SUW) and subjective percent of worry thought content were assessed for pre-experimental baseline, following each of the three induction sessions, and immediately upon completion of the last experimental task. A repeated measures ANOVA comparing the worry induction group with the neutral thought induction group revealed a significant interaction between thought induction condition and SUW $F(4,336) = 21.85$, $p < .05$. The worry and neutral thought induction groups did not show a difference in SUW at baseline. However, the worry induction group reported significantly higher levels of subjective worry following each of the three thought induction sessions than the neutral thought control group. These differences were maintained through the experimental phases with a return to baseline levels during the post-experimental baseline assessment. Table 5 provides means and standard deviations of SUW by induction condition across the assessment phases.

Table 5 Table of Means and Standard Deviations of Subjective Units of Worry by Thought Induction Group over Repeated Assessment Phases

	Thought Induction			
	Worry (n = 39)		Neutral Thought (n = 47)	
Assessment Phases	*M*	*SD*	*M*	*SD*
Pre-experimental Baseline	25.11	21.80	23.69	22.72
First Induction Session	44.62	23.08	10.73	13.68
Second Induction Session	41.64	22.98	10.51	13.68
Third Induction Session	41.72	20.83	10.85	14.63
Post-experimental Baseline	26.94	20.55	10.42	14.57

This same analytic procedure was repeated for self-reported percentage of worry thought content. Results revealed a significant interaction between self-reported percent of worry thought content and induction condition F (4,336) = 29.43, $p < .05$. The worry and neutral thought induction groups did not show a difference in self-reported percent of worry thought content at baseline. However, the worry induction group reported a significantly higher percentage of worry thought content following each of the three thought induction sessions than the neutral thought control group, and an increase in worry from baseline. These differences were maintained through the experimental phases with a return to baseline levels during the post-experimental baseline assessment. Table 6 provides means and standard deviations of percentages of self-reported worry thought content by induction condition across the assessment phases.

Table 6 Table of Means and Standard Deviations of Percentage of Worry Thought Content by Thought Induction Group over Repeated Assessment Phases

	Thought Induction			
	Worry (n = 39)		Neutral Thought (n = 47)	
Assessment Phases	*M*	*SD*	*M*	*SD*
Pre-experimental Baseline	28.00	23.58	28.23	26.37
First Induction Session	58.21	29.73	12.90	19.94
Second Induction Session	54.47	24.24	11.59	17.40
Third Induction Session	51.40	26.22	11.14	16.98
Post-experimental Baseline	32.72	24.38	12.29	18.16

Negative Affect

In order to assess differential changes in affect resulting from the thought induction manipulation, self report ratings of negative affect were assessed using the PANAS-N for pre-experimental baseline, following each thought induction session, and for post-experimental baseline. A repeated measures ANOVA comparing the worry induction group with the neutral thought induction group revealed a significant interaction between thought induction condition and negative affect ratings on the PANAS-N F (4,336) = 21.85, $p < .05$. The worry and neutral thought induction groups did not show a difference in negative affect at baseline. However, the worry induction group reported significantly higher levels of negative affect following each of the three thought induction sessions than the neutral thought control group. These differences were maintained through the experimental phases with a return to baseline levels for the worry induction group during the post-experimental baseline assessment. However, the neutral though induction group maintained the reduction in negative affect scores through

the post-experimental baseline assessment. Follow up repeated measures ANOVAs and pairwise comparisons examining change in negative affect over repeated assessments revealed that negative affect did not significantly increase from baseline in the worry induction group F (4,152) = 10.85, $p > .05$, but did significantly decrease from baseline in the neutral thought group F (4,184) = 2.18, $p < .05$. Consequently, differences between the groups were driven by decreased negative affect in the neutral thought group rather than by increased negative affect in the worry induction group. Table 7 provides means and standard deviations of negative affect scores on the PANAS-N by induction condition across the assessment phases.

Table 7 Table of Means and Standard Deviations of Negative Affect Scores on the PANAS-N by Thought Induction Group over Repeated Assessment Phases

	Thought Induction			
	Worry (n = 39)		Neutral Thought (n = 47)	
Assessment Phases	*M*	*SD*	*M*	*SD*
Pre-experimental Baseline	14.15	4.55	13.73	3.48
First Induction Session	15.68	4.36	11.63	2.19
Second Induction Session	15.17	5.03	11.57	2.02
Third Induction Session	14.96	4.72	11.50	1.76
Post-experimental Baseline	13.98	4.33	11.32	1.76

Attention

In order to assess differential changes in attention over the experiment as a result of the thought induction manipulation, a serial addition continuous performance test (SACPT) was administered at pre-experimental baseline and during the delay phase of each of the three subsequent inhibition tasks. Comparisons between the worry thought

induction and neutral thought induction groups on differences in reaction time and errors of omission were conducted using repeated measures ANOVAs. Results revealed no significant interaction between thought induction and mean reaction time on the (SACPT) F (3,252) = .52, $p > .05$. No significant change in reaction time was detected over the duration of the experiment F (4,252) = .11 $p > .05$. Nor was a significant difference between the thought induction groups on mean reaction time detected F (1,84) = .16, $p > .05$. Table 8 provides means and standard deviations of mean reaction times for the SACPT by induction condition across the assessment phases. Similarly, no significant interaction between thought induction and errors of omission on the (SACPT) was identified F (3,252) = .18, $p > .05$. No significant difference in errors of omissions between thought induction groups was detected F (1,84) = .08, $p > .05$. However, a significant change in errors of omissions over the course of the experiment was revealed F (3,252) = 7.74, $p < .05$. Errors of omission increased for both groups during each subsequent assessment of attention with the SACPT. Table 9 provides means and standard deviations of errors of omissions on the SACPT by induction condition across the assessment phases.

Table 8 Table of Means and Standard Deviations of Mean Reaction Times in Milliseconds for the SACPT by Thought Induction Group over Repeated Assessment Phases

	Thought Induction			
	Worry (n = 39)		Neutral Thought (n = 47)	
Assessment Phases	*M*	*SD*	*M*	*SD*
Pre-experimental Baseline	545.01	71.05	559.52	75.16
First Inhibition Task	536.84	62.61	558.53	80.52
Second Inhibition Task	533.38	66.03	559.37	82.73
Third Inhibition Task	545.95	71.92	567.51	81.65

Table 9 Table of Means and Standard Deviations of Errors of Omission on the SACPT by Thought Induction Group over Repeated Assessment Phases

	Thought Induction			
	Worry (n = 39)		Neutral Thought (n = 47)	
Assessment Phases	*M*	*SD*	*M*	*SD*
Pre-experimental Baseline	6.75	11.47	6.90	10.08
First Inhibition Task	6.63	12.43	8.47	17.05
Second Inhibition Task	9.93	17.16	10.46	20.91
Third Inhibition Task	11.59	18.08	12.84	25.25

Hypothesis Testing Analyses

REPEATED MEASURES ANALYSES OF COVARIANCE INCLUDING THOUGHT INDUCTION CONDITION, SEMANTIC ASSOCIATION TO WORRY-CATEGORY, AND WORD AFFECTIVE VALENCE

Trait Worry as a Predictor Variable

Repeated measures ANCOVAs were conducted independently for measures of volitional inhibition obtained with the Directed Forgetting Task (DFT) and measures of non-volitional inhibition obtained with Retrieval Practice Paradigm (RPP). Inhibition of words semantically associated and unassociated with worry categories served as repeated measures. Worry induction (worry vs. neutral thought), and word affective valence (positive vs. negative) served as between-subjects factors, and trait worry (PSWQ score) served as a continuous predictor. Current level of depressive symptoms (BDI score) was entered as a covariate in all the analyses to control for the effects of depressive symptoms. Table 10 provides means and standard deviations for percent volitional and non volitional inhibition based on worry induction condition, word affective valence condition, and word semantic association to worry.

Table 10 Table of Means and Standard Deviations of Percent Inhibition as a Function of Inhibition Type, Worry Induction Condition, Word Affective Valence, and Word Association with Worry Categories

		Worry Induction				Neutral Thought			
		Word Affect				Word Affect			
		Negative		Positive		Negative		Positive	
		n = 22		*n* = 25		*n* = 18		*n* = 21	
Inhibition Measure	Category Association	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
DFT	Worry Category	4.56	19.11	-3.03	22.32	-3.47	19.58	.58	17.45
	Non-worry Category	6.25	19.95	-.80	14.87	-.69	21.64	5.48	14.53
RPP	Worry Category	10.41	14.19	1.33	23.16	-.70	16.18	4.56	18.53
	Non-worry Category	4.17	19.20	2.67	19.65	5.56	21.58	8.73	11.93

Volitional Inhibition

The results revealed no significant effects or interactions for measures of volitional inhibition. However, a trend toward a significant 2-way interaction between word affective valence, and trait worry F (1,77) = 3.66, p = .059, and a trend toward a significant 3-way interaction between word affective valence, semantic association of stimuli with worry, and trait worry F (1,77) = 3.69, p = .058 were found.

To investigate the trend toward a 2-way interaction between word affective valence and trait worry for volitional inhibition, follow-up multiple regression analyses were conducted. The relationship between trait worry and volitional inhibition was

analyzed for negative and positive affect words independently. Mean percent volitional inhibition, which served as the criterion variable, was calculated by computing the mean of percent volitional inhibition across repeated measures of words semantically associated and unassociated with worry. Current level of depressive symptoms was controlled for in the analyses by entering BDI scores in Block 1. Trait worry measured by scores on the PSWQ was entered into Block 2 for each analysis as the predictor variable of interest. The results revealed that after controlling for current level of depressive symptoms, trait worry accounted for a significant increase in variance for the mean volitional inhibition of positive (R^2_{change} = .23; F_{change} [1, 43] = 12.49, $p < .05$) and negative words (R^2_{change} = .09; F_{change} [1, 37] = 4.39, $p < .05$). Trait worry differentially predicted mean volitional inhibition based on the negative or positive affective valence of words. Higher levels of trait worry were associated with higher levels of mean volitional inhibition of positive words (β = .52), but lower levels of mean volitional inhibition of negative words (β = -.34).

Follow up MANCOVAs were conducted to investigate the trend toward a 3-way interaction between word affective valence, semantic association of stimuli with worry, and trait worry for volitional inhibition. A MANCOVA was conducted to investigate the interaction between word affective valence and trait worry for measures of volitional inhibition of words semantically associated and unassociated with worry. Results revealed a significant interaction between word affective valence and trait worry for the volitional inhibition of words semantically associated with worry F (1,85) = 8.88, $p < .05$, but not for words semantically unassociated with worry F (1,85) = .0000005, $p > .05$. ANCOVAs to investigate the interaction between semantic association of words to worry and trait worry were conducted for groups receiving negative or positive affect words independently. Results revealed a significant interaction between semantic association to

worry and trait worry for the volitional inhibition of positive words F (1,43) = 4.10, p < .05, but not negative words F (1,37) = 1.29, p > .05.

In order to further investigate the relationship between trait worry and volitional inhibition of words based on their affective valence and semantic association with worry, multiple linear regression analyses were conducted for dependent measures of volitional inhibition including inhibition of negative and positive affect words semantically associated and unassociated with worry categories. Current level of depressive symptoms was controlled for in the analyses by entering BDI scores in Block 1. Trait worry measured by scores on the PSWQ was entered into Block 2 for each analysis as the predictor variable of interest. The results revealed that after controlling for current level of depressive symptoms, trait worry did not account for a significant increase in variance for the volitional inhibition of either negative words (R2change = .003; F_{change} [1, 37] = .10, p > .05) or positive words (R^2_{change} = .027; F_{change} [1, 43] = 1.22, p > .05) when those words were not semantically associated with worry categories. In contrast, when words were semantically associated with categories of worry, trait worry did account for a significant increase in variance for the volitional inhibition of positive words (R^2_{change} = .23; F_{change} [1, 43] = 12.90, p < .05), and negative words (R^2_{change} = .12; $_{change}$ [1, 37] F = 5.40, p < .05). For negative words semantically associated with worry categories, higher levels of trait worry were predictive of lower levels of volitional inhibition of these words (β = -.39, see Figure 6). In contrast, higher levels of trait worry were predictive of higher levels of volitional inhibition for positive words (β = .53, see Figure 7) that were semantically associated with worry categories.

Figure 6: Regression Line of PSWQ Scores as a Predictor of Percent Inhibition on the DFT for Negative Affect Words Semantically Associated with Categories of Worry

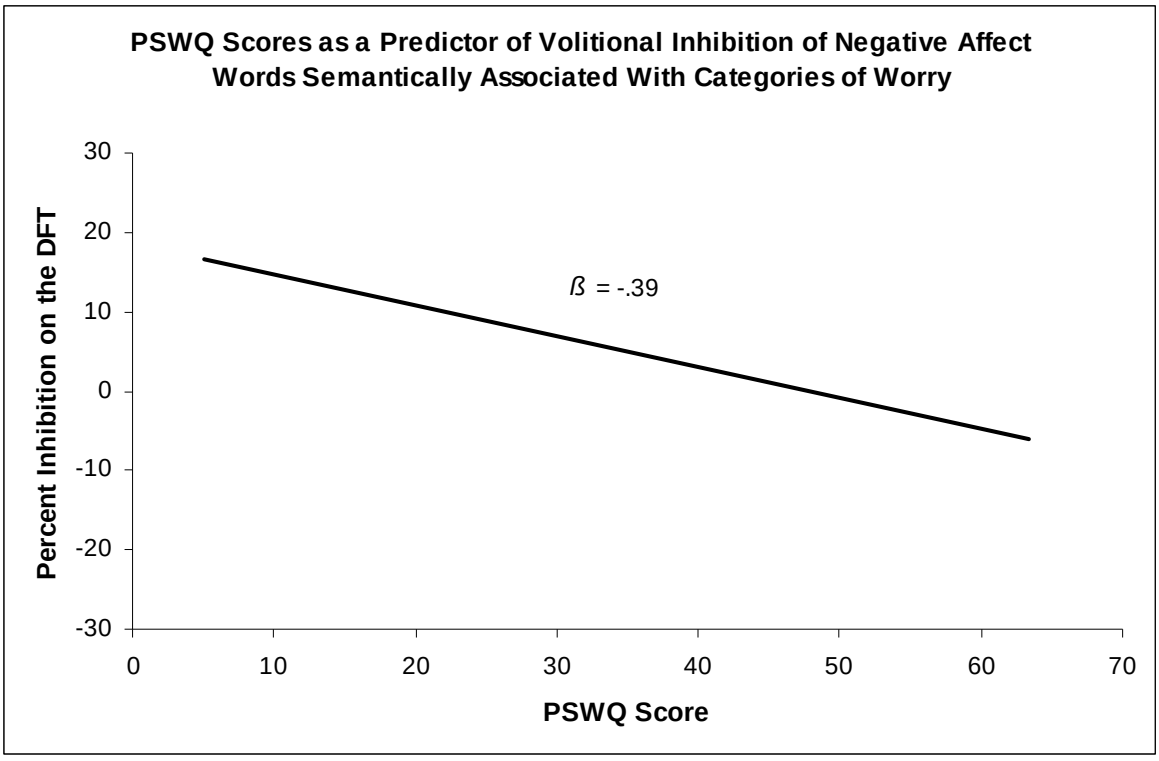
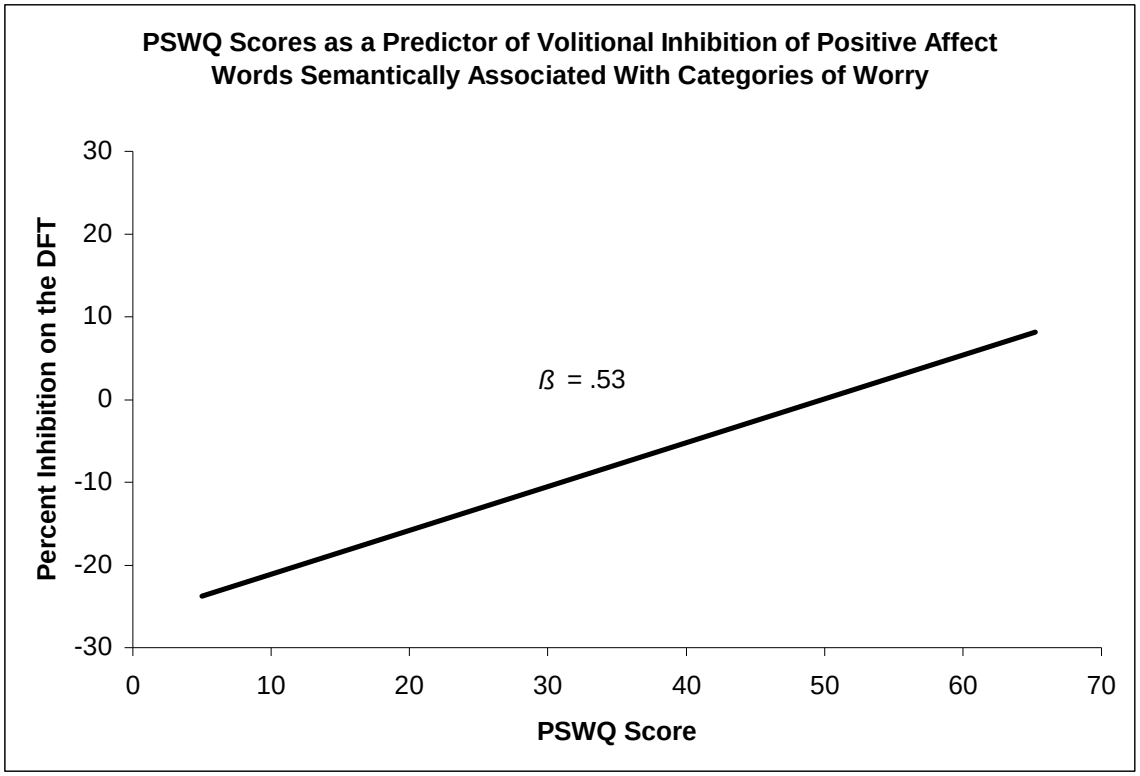


Figure 7: Regression Line of PSWQ Scores as a Predictor of Percent Inhibition on the DFT for Positive Affect Words Semantically Associated with Categories of Worry



Non-volitional Inhibition

Result revealed no significant effects or interactions for non-volitional inhibition based on thought induction, word affective valence, semantic association of words to worry, or trait worry.

Thought Suppression as a Predictor Variable

Repeated measures ANCOVAs including word stimuli association to worry categories (associated vs. not associated), worry induction (worry vs. neutral thought), and word affective valence (positive vs. negative) were conducted with thought

suppression (WBSI score) serving as a predictor for volitional and non-volitional inhibition independently. Current level of depressive symptoms (BDI score) was entered as a covariate to control for the effects of depressive symptoms.

Result revealed no significant effects or interactions for either volitional or non-volitional inhibition based on thought induction, word affective valence, semantic association of words to worry, or thought suppression.

TESTS OF MEDIATION

Analyses of Non-Volitional Inhibition as a Mediator for the Relationship between Volitional Inhibition and Trait Worry of Positive and Negative Words Semantically Associated with Worry Categories

Following the guidelines for tests of mediation set forth by the MacArthur approach (Kraemer, Kiernan, Essex, & Kupfer, 2008, Makinnon, 2008), testing the potential for non-volitional inhibition to serve as a mediator of trait worry on volitional inhibition the, a correlation between volitional inhibition and trait worry must first be established. As reported earlier, trait worry accounts for a significant amount of variance in volitional inhibition of both positive (R^2_{change} = .23) and negative words (R^2_{change} = .12) that are semantically associated with categories of worry when controlling for BDI scores. However, trait worry only accounts for a significant amount of the variance in volitional inhibition of positive words associated with worry when BDI scores are not entered (R^2 = .20; [1, 45] F = 11.26, $p < .05$). In the second step, the correlation between trait worry and non-volitional inhibition of positive words associated with categories of worry was investigated using Pearson's correlations. A trend toward a significant correlation between trait worry and non volitional inhibition was identified for positive words associated with worry categories (r = -.273, p =.67). Due to this trend, a regression analysis was conducted with both trait worry and non-volitional inhibition of

positive words associated with worry entered. The interaction between centered measures of trait worry and non-volitional inhibition was also entered into the model, and volitional inhibition of positive words associated with worry served as the criterion. Results revealed that non-volitional inhibition approached significance as a predictor of volitional inhibition ($t = 1.75$, $p < .092$) when trait worry was entered in the model. The interaction between trait worry and non-volitional inhibition was not a significant predictor of volitional inhibition when entered with trait worry ($t = .04$, $p > .05$)

As no relationship between measures of volitional inhibition and thought suppression were identified in the previous analyses, no tests of mediation were conducted for thought suppression.

DISCUSSION

Inhibition

Volitional and non-volitional inhibition both served as dependent measures in this study and were predicted to mirror one another with respect to the affect factors in this study would have on them. Even further, it was hypothesized that non volitional inhibition would serve to mediate the relationship between volitional inhibition and other factors such as trait worry and thought suppression. Unfortunately, no firm conclusions may be drawn from the results of the mediation analysis testing non-volitional inhibition as a mediator of trait worry on volitional inhibition. In the strict sense trait worry was not significantly correlated with the non-volitional inhibition of positive words associated with worry. Consequently, non-volitional inhibition failed to meet one of the criteria for mediation set forth in the MacArthur approach (Kraemer, Kiernan, Essex, & Kupfer, 2008, Makinnon, 2008), that the mediator be significantly correlated with the predictor. However, because the correlation between trait worry and non-volitional inhibition

approached significance, an exploratory test of mediation was conducted. It this case, non-volitional inhibition failed to reach, but approached significance as a potential mediator of trait worry on volitional inhibition. These results are equivocal, and indicate the possibility that non-volitional inhibition mediates the relationship between trait worry and volitional inhibition of positive words associated with worry.

Also contrary to predictions, non-volitional inhibition was not significantly affected by any of the experimental factors in this study, and was not significantly associated with the predictor variables investigated.

The findings from this study demonstrate a lack of consistent association between volitional and non volitional forms of inhibition, and an absence of study effects for non-volitional inhibition that were present for volitional inhibition. This calls into question the proposition that these differently conceptualized forms of inhibition function the same way in response to external influences or in association with individual difference factors. Whereas factors such as trait worry, semantic association of stimuli to worry, and affective valence of words may influence an individual's ability to volitionally forget information, non-volitional inhibition may be governed by other, more automatic processes less amenable to these influences.

Worry versus Neutral Thought Induction

In designing this study, the differential induction of worry in some participants and neutral thought in others was expected to exert the greatest influence on inhibition in memory. The effects that word affective valence and semantic association of words to worry had on inhibition were expected to be the most identifiable and strongest when worry was induced. In a previous study (Brown, Tucker, & Telch, unpublished manuscript) trait worry was found to differentially predict change in inhibition of neutral

words unassociated with worry following exposure to potential threat. Exposure to potential threat was believed to have activated worry for individuals, thus differentially affecting how individuals inhibit information in memory based on their trait tendency to worry. As such, the direct induction of worry was predicted to exert the greatest influence on the relationship between trait worry or thought induction and inhibition. Contrary to these predictions, differential thought induction did not significantly affect inhibition based on these factors. It did not significantly affect the association between trait worry or thought suppression and inhibition. Nor did it significantly interact with any other factors to affect the association between trait worry or thought suppression and inhibition.

Worry induction manipulation checks confirmed the successful induction of worry relative to the neutral thought based on self reported worry and percentage of thought content related to worry. However, the worry induction failed to result in any significant effect of induced worry on inhibition. The lack of effect of type of induced thought on inhibition or the association between trait worry or thought suppression and inhibition warrants exploration. The failure of induced worry to differentially affect the association between trait worry or thought suppression and inhibition, particularly non-volitional inhibition seems to contradict earlier findings that trait worry is associated with increased inhibition of neutral words, semantically unassociated with worry, following threat induction (Brown, Tucker, & Telch., unpublished manuscript). One major difference between these studies is that the effect of worry induction in this study was investigated as a between-subjects factor, whereas the effect of threat induction on inhibition in the Brown, Tucker, and Telch study (unpublished manuscript) was assessed by pre and post threat induction measures of inhibition. Assessing the effect of a manipulated variable by use of repeated measures is a much more powerful design

strategy and may account for the difference in findings between these studies. Another difference is that worry was induced in this study directly via thought induction procedures, whereas worry was not directly induced in the Brown, Tucker, and Telch study. This may mean that differences in inhibition associated with trait worry occur through activation of fear, rather than worry.

Word Affective Valence

Consistent with predictions, word affective valence was a significant factor in the association between volitional inhibition and trait worry. Individuals with a higher tendency toward worry show less volitional inhibition of negative words in memory and more volitional inhibition of positive words. This finding is consistent with prior research showing that worry is associated with, and increases negative affect (Borkovec at al. 1983; Beck, Perkins, Holder, Robbins, Gray, & Allison, 2001; York, Borkovec, Vasey, & Stern, 1987; Andrews & Borkovec, 1988; Borkovec & Inz, 1990). It raises the possibility that volitional inhibition may serve to mediate the relationship between worry and negative affect. A post-hoc test of mediation with volitional inhibition of negative words associated with worry as the hypothesized mediator for trait worry predicting baseline levels of negative affect revealed that both trait worry (t = 4.59, p <.01) and volitional inhibition (t = 2.39, p <.05) were significant predictors in the model. While the required temporal precedence for mediation could not be established here, these findings are consistent with what would be expected should volitional inhibition serve to mediate the relationship between trait worry and negative affect.

In addition to the potential mediator role, volitional inhibition of information in memory may serve to maintain worry through increased activation of negative information in individuals with a greater tendency to worry. The more readily accessible

negative thoughts are, the more likely they would be to prompt worry. Finding less inhibition of negative words associated with trait worry may also have implications with respect to negative rumination associated with depression. An individual's ability to volitionally inhibit the activation of negative information may play an important role in how well they can control negative thoughts characteristic of depression. Results from a regression analysis employing the same method as that exploring negative affect were replicated with BDI scores entered as the criterion variable with trait worry (t = 4.07, p <.01) and volitional inhibition of negative worry words (t = 2.79, p <.01) both significantly predicting BDI scores.

Semantic Association of Words to Categories of Worry

One of the most interesting findings from this study is that volitional inhibition in individuals high in trait worry is not only influenced by the affective valence of information, but also by the semantic association of information to common domains of worry. In fact, the findings indicate that the semantic association of words to worry plays a super ordinate role to affective valence in influencing the relationship between trait worry and volitional inhibition. In line with predictions, a higher tendency toward worry is significantly associated with less inhibition of negative words and more inhibition of positive words when those words are semantically associated with worry. However, when those words are semantically unassociated with worry, trait worry is not significantly associated with the volitional inhibition of either negative or positive words. What is most notable about these findings is that negative and positive affective material, both semantically associated with worry, are treated differently in memory based on an individual's tendency to worry. This is consistent with previous findings for the proposition that worry related information in memory is semantically organized (Craske,

et al., 1989; Sanderson & Barlow, 1990: Tallis, et al., 1992; Roemer, et al., 1997; Eysenck, 1984; Pratt, Tallis, & Eysenck, 1997; Provencher, Freeston, Dugas, Ladouceur, 2000). It also provides evidence consistent with Barlow's (1987) proposal that dual activation processes may be at work simultaneously within semantic nodes associated with mood or anxiety, or in this case, worry. Negative information, receiving less inhibition within a worry node would have a higher activation level, and positive information, receiving more inhibition within the same node would have lower levels of activation. Consequently, for individuals with a greater tendency to worry, negative information associated with their worry would have a higher activation level than positive information. This means that negative information associated with their worry would be more easily retrievable from memory during active periods of worry. Not only would this likely result in a greater tendency to experience negative affect, but it would also make it more difficult for an individual to access positive propositions about their worry helpful in countering the potential negative consequences they are worrying about.

In addition, this pattern of memory-based activation may serve as a potential mechanism for the maintenance of worry. Negative propositions associated with worry would pose a higher threat potential than positive propositions. If the activation of negative information in memory is boosted, while the activation of positive information is suppressed, the most easily retrievable information would be information with a greater threat potential, consequently prompting more worry. In support of this, Philippe, Lecours, and Beaulieu-Pellieter (2009) have proposed an Emotion Memories Network theory in which their research shows that accessibility of semantically related positive information in memory serves as a resilience factor protecting against emotional disruption. Consequently, individuals who show a greater tendency toward increased

inhibition of positive information and decreased inhibition of negative information would be at increased risk for emotional problems.

Clinical Implications

Findings from this study offer a number of important implications for further understanding GAD, the development of potential strategies related to the assessment and treatment of GAD, and the potential role of memory-based inhibition in other anxiety disorders such as PTSD or OCD.

In sum, the findings show that individuals with higher levels of trait worry tend to have a higher activation level for negative information in memory associated with worry, and lower activation level for positive information associated with worry. This provides a mechanism in memory through which pathological worry may be resistant to corrective information and self-perpetuating. In order for corrective information to provide treatment benefit for someone with GAD, they would need to be able to generate outcome alternatives to the negative outcomes they are focused on. Given the findings of this study, that may be a difficult proposition for someone with a strong tendency to worry. If positive information semantically associated with their worry is being actively suppressed in memory, retrieving this information to employ in reevaluating their worry would be more difficult. On the upside, the activation of this information is being volitionally suppressed. This implies the possibility that someone may be trained to exercise their intent to modify how active, and consequently accessible, corrective information related to their worry is. The recent success of attention training techniques in reducing naturalistic anxiety (See, MacLeod, & Bridle, 2009), and anxiety in GAD (Hazen, Vasey, Schmidt, 2009; Amir, Beard, Burns, & Bomyea, 2009) and social phobia (McEvoy & Perini, 2009) based on the work of Macleod and colleagues (2002), is potent

evidence for this possibility, and highlights the importance of identifying putative cognitive factors maintaining pathological levels of anxiety. The efficacy of attention retraining in reducing anxiety highlights its potential as a cognitive treatment component that may further enhance treatment efficacy. The identification of attention biases associated with anxiety has led to the development and investigation of attention training techniques as a strategy to reduce attention biases and consequent anxiety. Similarly, identification of memory processes as potential maintaining factors in anxiety, may lead to the development and implementation of memory retraining techniques with the potential of serving as an additional cognitive treatment component with the goal of enhancing treatment efficacy.

A primary diagnostic criterion for the diagnosis of GAD is uncontrollable worry. Given the properties of semantic networks in memory (Loftus, 1974; Anderson, 1976), the increased activation of negative information associated with worry, and concurrent suppression of positive information, would lead to a lower threshold for the activation of negative worry related information. Simply put, the more you worry, the less stimulation you need to activate your worry. This has important implications for treatments that employ worry exposure as it creates the potential to result in an adverse paradoxical effect on worry reduction.

Lastly, these findings may have important implications for understanding how factors in memory, such as inhibition, may play a role in the pathology of other anxiety disorders such as PTSD or OCD. Both PTSD and OCD involve intrusive cognitions in their pathology. The identification of memory based inhibitory processes associated with cognitive intrusions in these disorders would increase understanding of these disorders and may highlight memory as playing a particularly important role in them. In turn, considering how information might be differently processed in individuals dealing with

PTSD and OCD may provide ideas for additional cognitive treatment components that enhance treatment efficacy.

Limitations

The foremost limitation of this study was its scope and scale. This may have resulted in a number of adverse effects. For instance, the design required participants to engage in memory tasks and assessment tasks for approximately two uninterrupted hours. The quality of data collected from participants and potency of the worry inductions may have decreased over the duration of experimental administration despite self-reported assessment of worry by participants. Simple fatigue effects are known to affect the quality of data collection. Another potential mechanism would be loss of attentional focus over the experimental administration. The number of omission errors made by participants on the attention task utilized in this study significantly increased over the duration of the experiment across both the worry and neutral thought induction groups. These data support the contention participants' attention decreased over time. This may have adversely affected the quality of the data for the memory inhibition tasks. While counterbalancing controlled for the differential impact of such affects on task order or condition, there would still be a trend toward data collection with increased error during the later experimental stages. Consequently, all of the measures may have accumulated increased error variance, which may not have occurred with a more succinct study focus.

In addition to the effect of fatigue or loss of attention on measurement, they may have also negatively impacted the potency of the thought induction manipulation. It's not much of a stretch to posit that someone with decreased attention may be less able to follow instructions for a manipulation that asks them to control what they are thinking about. That is exactly what the worry induction attempts to do. Participants are asked to

worry about a topic they would normally worry about for 5 min. The worry induction was conducted three times over the duration of the experiment, prior to each memory task, in order to maximize the effects induced worry would have on inhibition just prior to assessing it. Consequently, fatigue or loss of attention, negatively affecting the potency of the worry manipulation, would potentially result in a more muted effect of worry on inhibition assessed in the later stages of the experiment. This possibility was assessed based on subjective units of worry (SUW) and self-reported percentage of thought content associated with worry, assessed following the initial worry induction and subsequent booster sessions. Participants in the worry induction group did not show a significant decline in how much worry they reported over the worry induction and booster sessions F (2,92) = 1.02, $p > .10$. However, they showed a decline that approached significance in the percentage of worry thought they reported engaging in during each subsequent booster following the initial worry induction F (2,92) = 2.71, p = .072. This later finding provides support for the proposition that participants' ability to successfully engage in worry decreased over the duration of the experiment as they reported a lower percentage of worry content over repeated assessments.

Another potential limitation of this study relates to manipulation potency. In contrast to earlier findings of changes in inhibition based on differential threat induction, differential induction of worry did not result in a consistently identifiable effect on inhibition. While a manipulation check of the worry induction based on self-report worry indicates the induction was successful, the absence in increased negative affect from baseline in the worry group raises doubts. Worry has been demonstrated to increase negative affect in previous research (Borkovec at al. 1983; York, Borkovec, Vasey, & Stern, 1987; Andrews & Borkovec, 1988; Borkovec & Inz, 1990; Beck, Perkins, Holder, Robbins, Gray, & Allison, 2001; Fresco, Frankel, Mennin, Turk, & Heimburg, 2002;

McLaughlin, Borkovec, & Sibrava, 2007). Consequently, the successful and sufficient induction of worry in this study should have resulted in increased negative affect from baseline for participants who underwent worry induction, but it did not.

It may simply be the case that induced worry does not affect inhibition in memory. However, other potential reasons should be considered. The successful induction of worry in a laboratory that realistically approximates naturally occurring worry may meet with challenges. The induction of worry in this study was performed by asking participants to engage in idiopathically identified worry. Unlike fear, which may be activated by the presentation of stimuli perceived as threatening, the successful induction of worry requires an individual to willfully engage in an aversive mental activity. Simple variability with respect to compliance will affect worry induction. In addition, individuals may simply vary in their ability to volitionally engage in worry that reasonably simulates naturally occurring worry. One factor that may influence this may simply be the ability of an individual to control their thought content. When someone engages in naturally occurring worry, purportedly the focus of that worry results because it is evaluated as important enough to demand attention at that time. This may result in the activation of a number of factors associated with naturally occurring worry that don't occur during a laboratory induction of worry.

Future Directions

These findings partially replicate previous research identifying an association between trait worry and inhibition (Brown, et al, unpublished manuscript). Consequently, suggested future directions for research in this area are proposed for investigating memory in anxiety, and for further investigating the role of memory based inhibition in the etiology and pathology of anxiety disorders.

Previous research has been inconsistent in demonstrating a memory bias related to anxiety (Bower, 1987; Mogg, Mathews, & Weineman, 1987; 1989; Mathews, 1990; Mathews & Macleod, 1994, Mathews & Milroy, 1994a). One potential reason for this may be that measures of memory, such as recall, employed in common methodologies may not be sensitive enough to detect the influence of anxiety on memory. Methodologies employing memory paradigms capable of yielding measures of activational processes in memory may prove better able to detect differences based on anxiety. To this end, the development of additional memory paradigms, tapping into various activational processes in memory, may serve to further advance research into the role of memory in anxiety.

Another application for future research in this area relates to the clinical implications and applications of these findings. Extension of this research to other areas of anxiety may yield potent confirmatory or contradictory evidence about the role of memory based inhibition in anxiety associated with both trait characteristics and disorder. One particularly promising research candidate in this regard would be an investigation of the role of memory based inhibition in PTSD. As common phenomena associated with PTSD may include continued reexperiencing of a trauma, or sensitization to respond fearfully to environmental cues one associates with the trauma, memory based inhibition may play an important role. Such investigations may address questions about individual differences in inhibiting information in memory as it relates to increased or decreased risk for PTSD onset following trauma exposure. In addition such research could evaluate whether dysinhibition or hyperinhibition predict symptom expression in PTSD. For example, is dysinhibition associated with primary symptom profile involving reexperiencing phenomena, and is hyperinhibition associated with a primary symptom profile of numbing?

Specific study designs offered for future research investigating the role of memory-based inhibition include replicating these findings by examining differences in volitional inhibition between participants meeting criteria for GAD and non-clinical controls, and a prospective PTSD study design investigating the potential of volitional inhibition to serve as a risk factor for the development of PTSD following trauma exposure. Comparing participants with GAD and non-clinical controls on change in inhibition pre-post worry induction based on the affective valence of words and their semantic association to worry would allow for further support or dismissal of the proposition that inhibition as a mechanism involved in pathological worry. In order to assess whether inhibitory functioning may serve as a risk factor in the development of PTSD, a prospective design strategy is proposed in which the inhibitory functioning of high risk first responders (i.e. police, EMT, fire department responders) is assessed upon completion of training, prior to employment in the field. Following trauma exposure, inhibition would be examined as a predictor of PTSD onset.

Appendices

APPENDIX A

Generation of Word Stimuli – Proposed Pilot Study

Generation of Word Stimuli – Word stimuli for the RPP and DFT was generated through a web-based study with three objectives: 1) Obtain a list of positive and negative affect words for four worry and four non-worry categories to be used in the RPP. 2) Obtain a list of positive and negative affect words for use in the DFT, both highly related and unrelated to worry, but that do not fall within the four categories to be used in the RPP. 3) Collect normative ratings for characteristics of each word including affective valence (positive vs. negative), association with worry, and association to category.

A list of nouns of approximately 1,300 were generated from existing studies using words with a positive or negative affective valence, studies using words associated with worry or anxiety, and words selected from the Webster's collegiate dictionary (11th edition) based on the potential potentially for the word to meet the aforementioned criteria. The selections of nouns enabled the generation for a set of stimuli that do not differ based on their part of speech. The generation of words within worry categories were chosen based on the most commonly reported spheres of worry including relationships, health, finances, and academics/work (Craske, Rapee, Jackel, & Barlow, 1989; Sanderson & Barlow, 1990; Tallis, Eysenck, & Mathews, 1992; Roemer, Molina, & Borkovec, 1997; Osman, Gutierrez, Downs, Koppler, Barrios, Haraburda, 2001). Following initial word generation, agreement between three independent raters resulted in the selection of the most likely words for to be rated in the web-study.

Normative data collected for the words from the web study was used to create a stimuli set for use in the RPP and DFT that controlled for differences in association strength and strength of affect. It further allowed for words to be assigned for use based on the manipulation of their categorical association to worry and affective valence.

APPENDIX B: QUESTIONNAIRES

Note: Copyrighted questionnaires are not included in this appendix.

Appendix B1: Penn State Worry Questionnaire

PSWQ

Enter the number that best describes how typical or characteristic each item is of you, putting the number next to the item.

1	2	3	4	5
Not at all typical		Somewhat typical		Very typical

___ 1. If I don't have enough time to do everything I don't worry about it.
___ 2. My worries overwhelm me.
___ 3. I don't tend to worry about things.
___ 4. Many situations make me worry.
___ 5. I know I shouldn't worry about things, but I just can't help it.
___ 6. When I am under pressure I worry a lot.
___ 7. I am always worrying about something.
___ 8. I find it easy to dismiss worrisome thoughts.
___ 9. As soon as I finish one task, I start to worry about everything else I have to do.
___ 10. I never worry about anything.
___ 11. When there is nothing more I can do about a concern, I don't worry about it any more.
___ 12. I've been a worrier all my life.
___ 13. I notice that I have been worrying about things.
___ 14. Once I start worrying, I can't stop.
___ 15. I worry all the time.
___ 16. I worry about projects until they are all done.

(Reverse-score items 1, 3, 8, 10, and 11, and then sum over 16 items.)

Appendix B2: Student Worry Questionnaire

Ψ **Name/Code #:** _____ **Gender: Male/Female** **AGE:**_____ **SWQ-30**

Date:___/___/____ **Marital Status:**_____ **Year in College:** _____

Below is a list of situations, events, feelings, and reactions related to worry. Please use the following rating scale (0, 1, 2, 3, 4) and circle a number to the right of each statement to describe how characteristic each statement is of you.

	0 = **Almost Never** characteristic of me	1 = **Rarely** characteristic of me	2 = **Occasionally** characteristic of me	3 = **Frequently** characteristic of me	4 = **Almost Always** characteristic of me
1. I worry a lot about many daily life events and situations.	0	1	2	3	4
2. I worry about getting bad grades in my courses.	0	1	2	3	4
3. I worry about embarrassing myself around other people (for example, professors, strangers, other students).	0	1	2	3	4
4. I worry about not having enough money for the basic necessities of life (for example, clothing, food, rent).	0	1	2	3	4
5. I worry about something terrible happening to a close family member.	0	1	2	3	4
6. I worry about saying the right thing when expressing my opinion in discussions with other people.	0	1	2	3	4
7. I worry about doing poorly on most exams or projects.	0	1	2	3	4
8. I worry that a close family member might become seriously ill or injured.	0	1	2	3	4
9. I feel physically tired and exhausted when I worry about things.	0	1	2	3	4
10. I worry a lot about past and future life events and situations.	0	1	2	3	4
11. I feel like I am worrying about something all the time.	0	1	2	3	4
12. I worry about running out of money.	0	1	2	3	4
13. I worry that a close family member might die.	0	1	2	3	4
14. No matter how hard I try, I cannot stop or control worrying about something.	0	1	2	3	4
15. I feel restless or irritable when I worry about things.	0	1	2	3	4
16. I worry about having a major financial crisis.	0	1	2	3	4
17. I worry about keeping up with or handling my academic workload.	0	1	2	3	4
18. It is hard for me to control how much I worry about events and situations.	0	1	2	3	4
19. I worry about the physical health of a close family member.	0	1	2	3	4
20. I worry about being well prepared for most exams or projects.	0	1	2	3	4
21. I have trouble concentrating on a task or work when I worry about things.	0	1	2	3	4
22. I worry about asking other people questions for fear of sounding dumb.	0	1	2	3	4
23. I worry about being financially secured in the future.	0	1	2	3	4
24. I worry about making a fool of myself around other people.	0	1	2	3	4
25. I experience muscular aches, tension, headaches or soreness when I worry about things.	0	1	2	3	4
26. I worry about the general well-being of a close family member (for example, emotional, financial, marital).	0	1	2	3	4
27. I worry about maintaining a minimum grade point (GPA) each semester.	0	1	2	3	4
28. My sleep is restless and disturbed when I worry about things.	0	1	2	3	4
29. I worry about what other people think about me.	0	1	2	3	4
30. I worry about taking out too many loans to pay for daily expenses.	0	1	2	3	4

Appendix B3: White Bear Suppression Inventory

WBSI

This survey is about thoughts. There are no right or wrong answers, so please respond honestly to each of the items below. Be sure to answer every item by circling the appropriate letter beside each.

A	B	C	D	E
Strongly Disagree	**Disagree**	**Neutral or Don't Know**	**Agree**	**Strongly Agree**

A B C D E 1. There are things I prefer not to think about.

A B C D E 2. Sometimes I wonder why I have the thoughts I do.

A B C D E 3. I have thoughts that I cannot stop.

A B C D E 4. There are images that come to mind that I cannot erase.

A B C D E 5. My thoughts frequently return to one idea.

A B C D E 6. I wish I could stop thinking of certain things.

A B C D E 7. Sometimes my mind races so fast I wish I could stop it.

A B C D E 8. I always try to put problems out of mind.

A B C D E 9. There are thoughts that keep jumping into my head.

A B C D E 10. There are things that I try not to think about.

A B C D E 11. Sometimes I really wish I could stop thinking.

A B C D E 12. I often do things to distract myself from my thoughts.

A B C D E 13. I have thoughts that I try to avoid.

A B C D E 14. There are many thoughts that I have that I don't tell anyone.

A B C D E 15. Sometimes I stay busy just to keep thoughts from intruding on my mind.

SCORING: Total the items with A=1, B=2, C=3, D=4, E=5. See Wegner & Zanakos (1994) for norms and interpretation.

Appendix B4: Generalized Anxiety Disorder Questionnaire-IV

GAD-Q-IV

1. Do you experience excessive worry? Yes___ No___

2. Is your worry excessive in intensity, frequency, or amount of distress it causes? Yes___ No___

3. Do you find it difficult to control your worry (or stop worrying) once it starts? Yes___ No___

4. Do you worry excessively and uncontrollably about minor things such as being late for an appointment, minor repairs, homework, etc.? Yes___ No___

5. Please list the most frequent topics about which you worry excessively and uncontrollably:

a._____ d._____

b._____ e._____

c._____ f._____

6. During the last six months, have you been bothered by excessive and uncontrollable worries more days than not? Yes___ No___

IF YES, CONTINUE. IF NO, SKIP REMAINING QUESTIONS.

7. During the past six months, have you often been bothered by any of the following symptoms? Place a check next to each symptom that you have had more days than not:

___ Restlessness or feeling keyed up or on edge

___ Difficulty falling/staying asleep or restless/unsatisfying sleep

___ Difficulty concentrating or mind going blank

___ Irritability

___ Being easily fatigued

___ Muscle tension

8. How much do worry and physical symptoms interfere with your life, work, social activities, family, etc.? Circle one number:

0	1	2	3	4	5	6	7	8
None		Mild		Moderate		Severe		Very Severe

9. How much are you bothered by worry and physical symptoms (how much distress does it cause you)? Circle one number:

0	1	2	3	4	5	6	7	8
No distress		Mild distress		Moderate distress		Severe distress		Very Severe Distress

APPENDIX C: PARTICIPANT INSTRUCTIONS

Appendix C1: RPP Instructions

Learning Phase

You will be presented a list of word pairs including a category and a word from that category. Each word pair will appear on the monitor by itself followed shortly by the next pair on the list. We would like you to try to learn all the words that are presented for each category.

Retrieval Practice Phase

Now you are going to see categories that you saw just a moment ago. The categories will be followed by two letters that provide a cue for one of the words you just learned in that category. When presented each category and cue, type in the complete word that is prompted by the cue provided. Make sure to pay careful attention to spelling and typos. If you make an error, hit the backspace key to make corrections. If the response you enter is correct, the next category and cue will be presented. If your response is incorrect, the same category will be presented again with another letter added to the cue for the correct word to aid you in identifying it. Once you receive the cue with the added letter, try to type in the correct word. If your response is again incorrect, this process will repeat.

Delay/Distraction Phase (Serial addition continuous performance task)

You will be presented with a series of single digits appearing one at a time. Try to remember the digit series in the order they are presented. After each digit series, there will be a short delay followed by a prompt to right down the digit series you were just presented. When you are given this prompt, write down the digit series across the line provided for it in the response book before you.

Free-recall Test Phase

You will be presented all of the categories, one at a time, from the list you learned at the beginning of this task. When you are presented with each category, write down as many words as you can from the list of words you just learned for that category.

Appendix C2: DFT Instructions

Before the DFT

You will be presented with a list of words appearing one at a time on the monitor before you. Try to learn as many of the words as you can, because at the end of the list we are going to test how many of the words you remember.

End of First List

Now we would like you to forget all of the words you just learned because they were just for practice and won't be part of the test. You're going to get a new list of words now. Try to learn as many of the new words as you can because the new words will be on your recall of the new words.

Free-recall Test

Please write down all of the words from the list you just saw. We would like you to write down both the words from the beginning of the list that you were asked to forget, and the words from the end of the list you were asked to remember. Just try to write down as many of the words as you can from all of the words you just saw.

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Vita

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